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Dated: May 20, 2013.

**Rachel Jacobsen,**

Principal Deputy Assistant Secretary for Fish and Wildlife and Parks.

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**DEPARTMENT OF COMMERCE****National Oceanic and Atmospheric Administration****50 CFR Part 224**

[Docket No. 101004485-3501-02]

RIN 0648-XZ50

**Endangered and Threatened Wildlife and Plants; 12-Month Finding and Proposed Endangered Listing of Five Species of Sawfish Under the Endangered Species Act****AGENCY:** National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.**ACTION:** Proposed rule; 12-month petition finding; request for comments.

**SUMMARY:** We, NMFS, have completed comprehensive status reviews under the Endangered Species Act (ESA) of five species of sawfishes in response to a petition to list six sawfish species. In our 90-day finding we determined that *Pristis pristis*, as described in the petition, was not a valid species and began our status review on the remaining five species (*Anoxypristis cuspidata*; *Pristis clavata*; *Pristis microdon*; *Pristis zijsron*; and all non-listed population(s) of *Pristis pectinata*). During our status review, new scientific information revealed that three previously recognized species (*P. microdon*, *P. pristis*, and *P. perotteti*) were in fact a single species, *Pristis pristis*. We had previously listed *P. perotteti* as an endangered species (July 12, 2011). We therefore also considered the information from our 2010 status review of *P. perotteti*, herein *P. pristis*. We have determined, based on the best scientific and commercial data available and after taking into account efforts being made to protect the species, that the narrow sawfish (*A. cuspidata*); dwarf sawfish (*P. clavata*); largetooth sawfish (collectively *P. pristis*; formerly *P. pristis*, *P. microdon*, and *P. perotteti*); green sawfish (*P. zijsron*); and the non-listed population(s) of smalltooth sawfish *P. pectinata* meet the definition of an endangered species. We also include a change in the scientific name

for largetooth sawfish in this proposed rule to codify the taxonomic reclassification of *P. perotteti* to *P. pristis*. We are not proposing to designate critical habitat because the geographical areas occupied by the species are entirely outside U.S. jurisdiction and we have not identified any unoccupied areas that are currently essential to the conservation of any of these species. We are soliciting information that may be relevant to these listing and critical habitat determinations, especially on the status and conservation of these species.

**DATES:** Comments on this proposed rule must be received by August 5, 2013. Public hearing requests must be made by July 19, 2013.

**ADDRESSES:** You may submit comments, identified by the following document number, NOAA-NMFS-2011-0073, by any of the following methods:

- **Electronic Submissions:** Submit all electronic public comments via the Federal eRulemaking Portal. Go to [www.regulations.gov/](http://www.regulations.gov/) #!docketDetail;D=NOAA-NMFS-2011-0073. click the "Comment Now" icon, complete the required fields, and enter or attach your comments.
- **Fax:** 727-824-5309; Attn: Assistant Regional Administrator for Protected Resources.

**Instructions:** You must submit comments by one of the above methods to ensure that we receive, document, and consider them. Comments sent by any other method, to any other address or individual, or received after the end of the comment period may not be considered. All comments received are a part of the public record and will generally be posted for public viewing on <http://www.regulations.gov> without change. All personal identifying information (e.g., name, address, etc.) confidential business information, or otherwise sensitive information submitted voluntarily by the sender will be publicly accessible. We will accept anonymous comments (enter "N/A" in the required fields if you wish to remain anonymous). Attachments to electronic comments will be accepted in Microsoft Word, Excel, or Adobe PDF file formats only.

You can obtain the petition, the proposed rule, and the list of references electronically on our NMFS Web site at <http://sero.nmfs.noaa.gov/pr/pr.htm>.

**FOR FURTHER INFORMATION CONTACT:** Shelley Norton, NMFS, Southeast Regional Office (727) 824-5312 or Dr. Dwayne Meadows, NMFS, Office of Protected Resources (301) 427-8403.

**SUPPLEMENTARY INFORMATION:**

**Background**

On September 10, 2010, we received a petition from the WildEarth Guardians (WEG) requesting we list six sawfish species: knifetooth, narrow, or pointed sawfish (*A. cuspidata*, hereinafter the narrow sawfish); dwarf or Queensland sawfish (*P. clavata*, hereinafter the dwarf sawfish); largetooth sawfish (*P. pristis* and *P. microdon*); green sawfish (*P. zijsron*); and the non-listed population(s) of smalltooth sawfish (*P. pectinata*) as endangered or threatened under the ESA; or alternatively to list any distinct population segments (DPS) that exist under the ESA. On March 7, 2011, we published a 90-day finding (76 FR 12308) stating the petitioned action may be warranted for five of the six species *A. cuspidata*, *P. clavata*, *P. microdon*, *P. zijsron*, and the non-listed population(s) of *P. pectinata*. Information in our records indicated that *P. pristis* as described in the petition, was not a valid species. Our 90-day finding requested information to inform our decision, and announced the initiation of status reviews for the five species. During the comment period we received five public comments.

We are responsible for determining whether species are threatened or endangered under the ESA (16 U.S.C. 1531 *et seq.*). To make this determination, we first consider whether a group of organisms constitutes a "species" under the ESA, then whether the status of the species qualifies it for listing as either threatened or endangered. Section 3 of the ESA defines a "species" as "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." Section 3 of the ESA further defines an endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range" and a threatened species as one "which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Thus, we interpret an "endangered species" to be one that is presently in danger of extinction. A "threatened species," on the other hand, is not presently in danger of extinction, but is likely to become so in the foreseeable future (that is, at a later time). In other words, the primary statutory difference between a threatened and endangered species is the timing of when a species may be in danger of extinction, either presently (endangered) or in the foreseeable future (threatened). Section 4(a)(1) of the ESA requires us to determine whether any

species is endangered or threatened due to any one or a combination of the following five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence. We are required to make listing determinations based solely on the best scientific and commercial data available after conducting a review of the status of the species and after taking into account efforts being made by any state or foreign nation to protect the species.

In making listing determinations for these five species, we first determine whether each petitioned species meet the ESA definition of a "species". Next, using the best available information gathered during the status reviews, we complete an extinction risk assessment using the general procedure of Wainwright and Kope (1999). We then assess the threats affecting the status of each species using the five factors identified in section 4(a)(1) of the ESA.

Once we have determined the threats, we assess efforts being made to protect the species to determine if these conservation efforts were adequate to mitigate the existing threats. We evaluate conservation efforts using the criteria outlined in the joint NMFS and U.S. Fish and Wildlife Service (USFWS) Policy for Evaluating Conservation Efforts (PECE; 68 FR 15100; March 28, 2003) to determine their certainty of implementation and effectiveness for future or not yet fully implemented conservation efforts. Finally, we re-assess the extinction risk of each species in light of the existing conservation efforts.

### Status Reviews

In order to conduct a comprehensive review, NMFS Southeast Region Protected Resources Division and NMFS Southeast Fisheries Science Center, Panama City Laboratory, staff members collaborated to identify the best available information. Unlike some previous 12-month findings from this agency, we have not developed a separate status review report. Instead, we present all information available for these species in this **Federal Register** notice; we first discuss background information relative to all five species and then include descriptions of the natural history specific to each species.

### Sawfish General Species Description

Sawfishes are a group of shark-like rays. Taxonomically they are classified in the Family Pristidae (sawfishes), Order Rajiformes (skates, rays, and sawfishes) and Class Chondrichthyes (cartilaginous fish), also commonly known as elasmobranchs. The overall body form of sawfishes is similar to sharks, but they are flattened dorso-ventrally. Sawfishes are covered with dermal denticles (teeth-like scales) and possess enlarged pectoral fins.

The most distinct characteristic of sawfishes is their large, flat, toothed rostrum or 'saw' with large teeth on each side. The rostral teeth are made from calcified tissue that is neither dentin nor enamel, though it is more similar to the latter (Bradford, 1957). Rostral teeth develop inside sockets on the rostrum and are held in place by strong fibers. Unlike sharks, sawfish rostral teeth are not replaced, although partially broken teeth may continue to grow (Miller, 1974). For some species of sawfish, the number of rostral teeth can vary by geographic region.

Sawfishes use their rostrum to locate, stun, and kill prey, generally small schooling fishes such as mullet, herring, shad, and sardines (Bigelow and Schroeder, 1953). Breder (1952), in summarizing the literature on observations of sawfish feeding behavior, noted that they attack fish by slashing sideways through schools of fish, and then impale the fish on their rostral teeth. Prey are subsequently scraped off their rostral teeth by rubbing the rostrum on the bottom and then ingesting the whole fish. Bigelow and Schroeder (1953) also report that sawfish feed on crustaceans and other benthic species. Recent studies indicate that sawfishes may use their toothed rostrum to sense their prey's electric fields (Wueringer *et al.*, 2011; 2012).

All sawfish species are distributed primarily in circumtropical shallow coastal waters that generally vary in salinity. While sawfishes are commonly found in shallow water, adults are known to also inhabit deeper waters (greater than 130 ft, 39.6 m). Some sawfishes are found in freshwater, with established populations in major rivers and lakes of South America, Africa, and southeast Asia. The physical characteristics of habitat, such as salinity and temperature, likely influence a sawfish's movement patterns. Tides limit the physical habitat area available, which may explain movement into shallow water areas during specific tidal cycles (Blaber *et al.*, 1989).

Life history data on sawfishes are limited. Fertilization is internal by means of male claspers and reproduction is ovoviviparous; females carry eggs with a yolk sac that nourishes developing young until they hatch within the body. Sawfishes are born with a gelatinous substance around their rostral teeth to protect the mother during birth (Last and Stevens, 1994; Rainboth, 1996; Compagno and Last, 1999; Raje and Joshi, 2003; Field *et al.*, 2009). It is thought that most sawfishes breed every two years and have a gestation period of about four to five months (Bigelow and Schroeder, 1953; Thorson, 1976a). The number of young in a litter varies by species, as does the age at sexual maturity.

Like most chondrichthyes, sawfishes occupy the mid to upper level of the food web. Smaller sawfishes, including juveniles, may be preyed upon by larger sharks like the bull shark (*Carcharhinus leucas*), estuarine crocodiles (*Crocodylus porosus*) or alligators (*Alligator mississippiensis*). Sawfishes may use their saw as a weapon for defense against these predators (Brewer *et al.*, 1997; Wueringer *et al.*, 2009).

Previously, seven valid species of sawfish were recognized worldwide (Compagno, 1999). Per Compagno and Cook (1995) and Compagno (1999) these are *A. cuspidata* (Latham 1794), *P. microdon* Latham 1794, *P. perotteti* Muller & Henle 1841, *P. pristis* (Linnaeus 1758), *P. clavata* Garman 1906, *P. pectinata* (Latham 1794), and *P. zijssron* (Bleeker 1851). Since then, the taxonomy, delineation, and identification of these species have proven problematic (Oijen *et al.*, 2007; Wiley *et al.*, 2008; Wueringer *et al.*, 2009). Most recently, Faria *et al.* (2013) hypothesized that the taxonomic uncertainty occurred due to several factors: many original species descriptions were abbreviated, few holotypes are available for examination, reference material is not available for comparison in museum collections, and it is difficult to obtain fresh specimens because of the infrequent captures of all sawfishes. The majority of the confusion regarding taxonomic classification of Pristidae was related to the species *P. pristis*. To resolve these questions regarding the taxonomy of pristids, Faria *et al.* (2013) used historical taxonomy, external morphology, and mitochondrial DNA (mtDNA) sequences (NADH-2 loci) to hypothesize that the sawfishes comprise five species in two genera: *P. pristis*, *P. clavata*, *P. pectinata*, *P. zijssron*, and *A. cuspidata*. We accept this proposed taxonomy as the best available science at this time.

### Natural History of the Narrow Sawfish (*Anoxypristis cuspidata*)

#### Taxonomy and Morphology

The narrow sawfish was first described by Latham in 1794 as *P. cuspidatus*. It was later reclassified as *Anoxypristis* due to morphological differences from *Pristis* that include its narrow rostral saw, which lacks teeth on the first quarter of the saw closest to the head in adults, and the distinct shape of the lower lobe of the caudal fin (Compagno *et al.*, 2006a). In juveniles the portion of the rostrum without teeth is only about one-sixth of the saw length (Wueringer *et al.*, 2009).

In addition, the narrow sawfish is characterized by dagger-shaped rostral teeth (Fowler, 1941; Blegvad and Loppenthin, 1944; Compagno and Last, 1999; Faria *et al.*, 2013). The narrow sawfish also has a second pair of lateral canals in its rostrum that are not present in other sawfishes. These canals contain an additional connection to the ampullae of Lorenzini located on the underside of the rostrum (Wueringer *et al.*, 2009).

Rostral tooth count varies for this species between 18–22 (Last and Stevens, 1994), 24–28 (Hussakof, 1912), and 27–32 (Miller, 1974). Total number of teeth has been found to vary by individual, region, and sex. Some studies report males having fewer rostral teeth than females, and others the opposite (Last and Stevens, 1994; Compagno and Last, 1999). While total rostral tooth count is often inconsistent among individuals or studies, the number of teeth an individual has is fixed during development (Wueringer *et al.*, 2009).

The pectoral fins of the narrow sawfish are narrow, short, and shark-like in shape. The first dorsal fin is located posterior to the insertion of the pelvic fins (Compagno and Last, 1999). Within the jaw, there are 94 teeth on the upper jaw and 102 on the lower jaw (Taniuchi *et al.*, 1991a). The eyes are large and very close to the spiracles. Coloration is dark grey dorsally and whitish ventrally (Fowler, 1941; Compagno and Last, 1999).

Narrow sawfish are the only sawfish having tricuspid (three-pointed) denticles (White and Moy-Thomas, 1941). Because these denticles first appear on neonate sawfish at 25.6–28 in (65–71 cm) total length (TL), they are developed post-natally. In general, the narrow sawfish is considered “naked” because denticle coverage in adults is often sporadic and widely spaced, usually only covering the rostrum and anterior fin margins, making the skin appear smooth (Fowler, 1941; Gloerfelt-

Tarp and Kailola, 1984; Last and Stevens, 1994; Wueringer *et al.*, 2009). Narrow sawfish also have buccopharyngeal denticles present in their mouth. This species does not have tubercles or thorns on their skin (Deynat, 2005).

#### Habitat Use and Migration

The narrow sawfish is largely euryhaline and moves between estuarine and marine environments (Gloerfelt-Tarp and Kailola, 1984; Last, 2002; Compagno, 2002b; Compagno *et al.*, 2006a; Peverell, 2008). It is generally found in inshore waters in depths of less than 130 ft (39.6 m) with salinities between 25 and 35 parts per thousand (ppt), spending most of its time near the substrate or in the water column over coastal flats (Compagno and Last, 1999; Last, 2002; Peverell, 2005; Peverell, 2008; Wueringer *et al.*, 2009). While Smith (1936) described it as a possible freshwater species, there are only a few reports from freshwater (Taniuchi and Shimizu, 1991; Last and Compagno, 2002; Bonfil and Abdallah, 2004; Wueringer *et al.*, 2009). We are not aware of any fresh or salt water tolerance studies on the species (Compagno, 2002a; Compagno, 2002b) and conclude its habitat is euryhaline.

In studies conducted by Peverell (2008), the narrow sawfish in the Gulf of Carpentaria, Australia undergo an ontogenetic shift in habitat. Larger individuals were commonly encountered offshore, while smaller individuals were mostly found in inshore waters. Peverell (2008) also found females were more likely to be offshore compared to males, at least during the months of the study (February to May). This suggests that smaller narrow sawfish use the protection and prey abundance found in shallow, coastal waters (Dan *et al.*, 1994; Peverell, 2005; Peverell, 2008).

#### Age and Growth

Two studies have been conducted on age and growth of narrow sawfish. Field *et al.* (2009) compared previously-aged vertebrae with aged rostral teeth and found a direct correlation up to age 6. After age 6, an individual's age was often underestimated using tooth growth bands as the teeth become worn over time (Field *et al.*, 2009). Peverell (2008) then used aged vertebrae to develop more accurate growth curves for both sexes. While the maximum observed age of narrow sawfish from vertebrae was 9 years, the theoretical longevity was calculated at 27 years (Peverell, 2008). At an age of one year, saw length is approximately 4.5 in (11.5 cm). Female narrow sawfish begin to

mature at 8 ft 1 in (246 cm) TL and all are mature at 15 ft 5 in (470 cm) TL; males are mature at 8 ft (245 cm) TL (Pogonoski *et al.*, 2002; Bonfil and Abdallah, 2004; Peverell, 2005; 2008). The maximum recorded length of a narrow sawfish is 15 ft 5 in (4.7 m) TL, with unconfirmed records of 20 ft (6.1 m) TL (Last and Stevens, 1994; Compagno and Last, 1999; Pogonoski *et al.*, 2002; Bonfil and Abdallah, 2004; Faria *et al.*, 2013).

#### Reproduction

The narrow sawfish gives birth to a maximum of 23 pups in the spring. The total length (TL) of pups at birth is between 17–24 in (43–61 cm) (Compagno and Last, 1999; Peverell, 2005; 2008). The reproductive cycle is assumed to be annual, with an average of 12 pups per litter (Peverell, 2005; D'Anastasi, 2010). The number of pups is related to female body size, as smaller females produce fewer offspring than larger females (Compagno and Last, 1999). Preliminary genetic research suggests that the narrow sawfish may not have multiple fathers per litter (D'Anastasi, 2010).

Female narrow sawfish captured in August (dry season) in the Gulf of Carpentaria, Australia, all contained large eggs indicating they were mature (Peverell, 2005). Mature males were also captured in similar locations during the same time of year (McDavitt, 2006). Although sexually mature, mating may not occur until the rainy season in March-May (Raje and Joshi, 2003).

Age at maturity for narrow sawfish is 2 years for males and 3 years for females (Peverell, 2008). The intrinsic rate of population increase (rate of growth of the population) based on life history data from the exploited population in the Gulf of Carpentaria, Australia, has been estimated at 0.27 per year (Moreno Iturria, 2012), with a population doubling time of 2.6 years.

#### Diet and Feeding

Narrow sawfish feed on small fish and cuttlefish (Compagno and Last, 1999; Field *et al.*, 2009) and, likely, crustaceans, polychaetes, and amphipods (Raje and Joshi, 2003).

#### Population Structure

Genetic and morphological data support the division of the global species of narrow sawfish into subpopulations (Faria *et al.*, 2013). Based on gene sequence data, there is a very low level of gene flow between the northern Indian Ocean (N=2) and west Pacific (N=11) populations. In a qualitative analysis when data were pooled, four haplotypes were identified:

northern Indian Ocean; Indonesian; New Guinean-Australian; and a northern Indian Ocean haplotype from a single specimen that lacked capture location (Faria *et al.*, 2013). A morphological distinction in narrow sawfish between the Indian Ocean and western Pacific Ocean subpopulations occurs in the number of rostral teeth (Faria *et al.*, 2013). Specimens collected from the Indian Ocean had a higher number of rostral teeth per side than those collected from the western Pacific.

Field *et al.* (2009) examined the primary chemical components of rostral teeth (i.e., oxygen, calcium, and phosphorous) from narrow sawfish captured throughout Australia in an attempt to separate subpopulations based on the isotopes of these chemicals. They found distinctions between regions indicating two separate subpopulations within the Gulf of Carpentaria Australia: one in the west (Northern Territory) and one in the east (Queensland). However, we realize that using isotopes to separate elasmobranch populations is in its infancy and, coupled with the limited number of samples, it is not yet clear whether these results agree with the above genetic studies of population structure. Isotopic signatures indicate the location where an animal spends most of its time and identifies its major prey resources, and do not necessarily provide information on reproductive connectivity between regions. Therefore, we conclude that the best available information on isotopic signatures does not support separating narrow sawfish into subpopulations.

#### *Distribution and Abundance*

The narrow sawfish is found throughout the eastern and western portions of the Indian Ocean as well as much of the western Pacific Ocean. The range once extended from as far west as the Red Sea in Egypt and Somalia (M. McDavitt pers. comm. to IUCN, 2012) to as far north as Honshu, Japan, including India, Sri Lanka, and China (Blaber *et al.*, 1994; Last and Stevens, 1994; Compagno and Last, 1999; Compagno *et al.*, 2006a; Van Oijen *et al.*, 2007). The species has also been recorded in rivers in India, Burma, Malaysia, and Thailand (Compagno, 2002b).

While uncertain, the current status of narrow sawfish populations across its range has declined substantially from historic levels. The species was previously commonly reported throughout its range but it is now becoming rare in catches by both commercial and recreational fishers (Brewer *et al.*, 2006; Compagno *et al.*, 2006a). To evaluate the current and historic distribution and abundance of

the narrow sawfish, we conducted an extensive search of peer-reviewed publications and technical reports, newspaper, and magazine articles. The result of that search is summarized below by major geographic region.

#### *Indian Ocean*

The earliest reports of narrow sawfish in the Indian Ocean were from 1937 and 1938. Two sawfish were captured from the northern Indian Ocean (no specific location was reported). A third specimen was later caught in the same area (Blegvad and Loppenthin, 1944).

From areas in the western Indian Ocean around the Arabian Sea, three rostra were collected in 1938: two near Bushire, Iran, presumably from the Gulf of Oman, and a third in Jask, Iran, also adjacent to the Gulf of Oman (Blegvad and Loppenthin, 1944). The most extensive report was 13 rostra from the Persian Gulf (one of those was from Iran) but it did not include date information (Faria *et al.*, 2013). Four juveniles were recorded in Pakistan waters in 1975; two females and two males.

Most records of narrow sawfish in the Indian Ocean are from the Bay of Bengal. In 1960 and 1961, 118 sawfish, mostly narrow sawfish, were captured during fishery surveys using gillnets and long lines (James, 1973). There are several additional records of rostra from Bangladesh in the 1960s (Faria *et al.*, 2013). A narrow sawfish was used for a 1969 parasitological study in Bangladesh but no further information was recorded (Moravec *et al.*, 2006). Faria *et al.* (2013) also reported one specimen from 1976, as well as eleven more records off India, but no dates were recorded. From 1982–1994, one juvenile female, one juvenile male, and three rostra were recorded in Pondicherry, India (Deynat, 2005). Two female neonate specimens were recorded in Sri Lanka, and three juveniles (two males and one female) from Malabar in southwest India were also reported from 1982–1994 (Deynat, 2005). Between 1981–2000, in the Bay of Bengal, total elasmobranch landings records are dominated by rays, but include narrow sawfish (Raje and Joshi, 2003).

Landings of narrow sawfish are currently reported from the Indian Ocean off India although they are infrequent (K.K. Bineesh pers. comm. to IUCN, 2012). The last published record of narrow sawfish from the western edge of the range, in the Straits of Hormuz, was in 1997 (A. Moore pers. comm. to IUCN, 2012).

#### *Indo-Pacific Ocean (excluding Australia)*

There are several accounts of narrow sawfish over time from various unspecified locations throughout the Indo-Pacific. The first records of narrow sawfish were for juvenile males in 1852 and 1854 (Faria *et al.*, 2013). In 1952, two females were captured from Batavia, Semarang, Indonesia along with a third female without a rostrum (Van Oijen *et al.*, 2007). Both a female and male were recorded in 1867. Prior to 1879, one male and one female were also recorded from Indonesia and four rostra were reported from China in 1898 (Faria *et al.*, 2013).

The next reports of narrow sawfish from the Indo-Pacific occurred in the 1930's. A female was reported in 1931 in Indonesia (no specific location), and a male in Singapore in 1937 (Blegvad and Loppenthin, 1944). A narrow sawfish was caught in the Gulf of Thailand in March 1937 (Blegvad and Loppenthin, 1944). A single report from Papua-New Guinea was recorded in 1938 (Faria *et al.*, 2013). In 1945, narrow sawfish were reported in the Chao Phraya River, Thailand and its tributaries (Smith, 1945).

Records of narrow sawfish throughout the Indo-Pacific continue to be scattered and infrequent throughout the 1950's. Faria *et al.* (2013) recorded rostra from Papua-New Guinea; two from 1955, one each from 1966, 1980, and 2000. A male was caught in 1989 from the Oriomo River, Papua-New Guinea (Taniuchi *et al.*, 1991b; Taniuchi and Shimizu, 1991; Taniuchi, 2002). There are other reports of narrow sawfish from Papua-New Guinea around the Gulf of Papua and in Bootless Bay from the 1970's, but there are no recent records (Taniuchi *et al.*, 1991b). In a comprehensive literature search for the period 1923–1996 on the biodiversity of elasmobranchs in the south China Sea, Compagno (2002a) found no records of sawfishes. However, fresh dorsal and caudal fins of narrow sawfish were found during a survey of fish markets from 1996–1997 in Thailand (Manjaji, 2002b).

There are even fewer records of narrow sawfish from the Indo-Pacific over the last few decades. The only known specimen in the 21st century is a single report from New Guinea in 2001 (L. Harrison pers. comm.).

#### *Australia*

Australia may have larger populations of narrow sawfish than any other area within the species range (Peverell, 2005). The earliest record of narrow sawfish is from 1926 from Sydney (Pogonoski *et al.*, 2002). We found no

reports of narrow sawfish from Australia from 1926 until the 1990s. Two narrow sawfish were reported from the Gulf of Carpentaria in 1990 (Blaber *et al.*, 1994). Single specimens were captured in 1991 from the west coast of Australia (Alexander, 1991), the Gulf of Carpentaria in 1995 (Brewer *et al.*, 1997) and the Arafura Sea in 1999 (Beveridge *et al.*, 2005). Faria *et al.* (2013) reported 3 rostra records from private collections in Australia from 1998–1999, but no other information on the collection location was reported.

Narrow sawfish have been reported in multiple studies between 2000 and 2011, mostly from northern Australia. In a bycatch reduction device study conducted in 2001 in the Gulf of Carpentaria, 25 narrow sawfish were captured in trawling gear (Brewer *et al.*, 2006). A survey of fisheries data and records identified 74 offshore and 37 inshore records of narrow sawfish in the Gulf of Carpentaria (Peeverell, 2005). Between April 2004 and April 2005, 16 narrow sawfish were caught in the Gulf of Carpentaria during a trawl bycatch study; the mean catch rate was 0.16 sawfish per hour (Dell *et al.*, 2009). Observers on commercial fishing boats recorded nine captures of narrow sawfish in 2007 within the Great Barrier Reef World Heritage Area, Queensland, which accounted for 0.86 percent of the shark and ray catch in the commercial fisheries (Williams, 2007). Observers in the Northern Territory's Offshore Net and Line Fishery encountered several narrow sawfish from 2007–2010 (Davies, 2010). Data from the Kimberley, Australia (R. McAuley pers. comm. to C. Simpfendorfer, 2012), the Northern Territory (Field *et al.*, 2009), the Gulf of Carpentaria (Peeverell, 2005), and parts of the Queensland east coast (Harry *et al.*, 2011) suggest viable subpopulations may remain locally, but at significantly lower levels compared to historic levels.

In summary, it appears the current range of narrow sawfish is restricted largely to Australia. Narrow sawfish are considered very rare in many places where evidence is available, including parts of India (Roy, 2010), Bangladesh (Roy, 2010), Burma (FIRMS, 2007–2012), Malaysia (including Borneo; Almada-Villela 2002; Manjaji, 2002), Indonesia (White and Kyne, 2010), Thailand (CITES, 2007; Compagno, 2002a; Vidhayanon, 2002), and Singapore (CITES, 2007). In Australia, narrow sawfish are primarily located in the northern area. For example, a bycatch reduction device study conducted in 2001 reported narrow sawfish in the Gulf of Carpentaria, a similar study conducted off the eastern coast did not capture a single specimen

(Courtney *et al.*, 2006). The most recent museum record for narrow sawfish in southern Australia was from New South Wales in the 1970s (Pogonoski *et al.*, 2002). Data from the Queensland Shark Control Program, conducted along the east coast of Queensland, from 1969–2003 shows a clear decline in sawfish catch (although not species-specific) with the complete disappearance of sawfish in southern regions of Queensland by 1993 (Stevens *et al.*, 2005). Although we cannot rule out underreporting of narrow sawfish, especially in remote areas of its historic range, we conclude from the consistent lack of records that narrow sawfish have been severely depleted in numbers and their range has contracted.

### Natural History of Dwarf Sawfish (*Pristis clavata*)

#### Taxonomy and Morphology

Due to its small size and geographic location where it was described, *P. clavata* is referred to as the dwarf or the Queensland sawfish. The species was first described by Garman in 1906; however it has often been confused with the smalltooth sawfish or largetooth sawfish species complex (Last and Stevens, 1994; Cook *et al.*, 2006; Morgan *et al.*, 2010a) given the lack of distinct characters. Ishihara *et al.* (1991a) provides the most concise review of the physical characteristics of the dwarf sawfish.

The dwarf sawfish is olive brown in color dorsally with a white underside. The rostrum of this species is quite short, with 19–23 rostral teeth that are moderately flattened, elongated, and peg-like. Studies indicate that this species does not display significant differences in the number of rostral teeth between males (19–23 teeth) and females (20–23 teeth) (Ishihara *et al.*, 1991a; Thorburn *et al.*, 2008; Morgan *et al.*, 2010a; Morgan *et al.*, 2011). This species can be distinguished from largetooth sawfish based on tooth morphology as described by Thorburn *et al.* (2007). The rostrum makes up 21–26 percent of the total length of the dwarf sawfish (Blaber *et al.*, 1989; Grant, 1991; Last and Stevens, 1994; Compagno and Last, 1999; Larson *et al.*, 2006; Wueringer *et al.*, 2009; Morgan *et al.*, 2011).

Morphologically, the origin of the first dorsal fin is slightly posterior to the insertion of the pelvic fins, and the second dorsal fin is smaller than the first. The pectoral fins are small, compared to other sawfish species, and are “poorly developed” (Ishihara *et al.*, 1991a). There is no lower lobe on the caudal fin. Lateral and low keels are

present along the base of the tail (Compagno and Last, 1999; Wueringer *et al.*, 2009; Morgan *et al.*, 2010a; Morgan *et al.*, 2011). Within the mouth are 82–84 tooth rows on the upper jaw. Total vertebrae number is 225–231. The dwarf sawfish has regularly overlapping monocuspidate denticles on its skin. As a result, there are no keels or furrows formed on the skin (Fowler, 1941; Last and Stevens, 1994; Deynat, 2005).

#### Habitat Use and Migration

The dwarf sawfish has been found along tropical coasts in marine and estuarine waters, mostly from northern Australia; it may inhabit similar habitats in other areas. Dwarf sawfish are reported on mudflats in water 6 ft 7 in to 9 ft 10 in (2–3 m) deep that is often turbid and influenced heavily by tides. This species has also been reported in rivers (Last and Stevens, 1994; Wueringer *et al.*, 2009; Morgan *et al.*, 2010a) and as commonly occurring in both brackish and freshwater, and in both marine and estuarine habitats (Rainboth, 1996; Thorburn *et al.*, 2008).

Juvenile dwarf sawfish may use the estuaries associated with the Fitzroy River, Australia as nursery habitat for up to three years (Thorburn *et al.*, 2008). Dwarf sawfish are also known to use the Gulf of Carpentaria, Australia as nursery area (Gorham, 2006). No adults or juveniles were found in freshwater areas of the river during the time of the study. However, physical characteristics such as salinity, temperature, and turbidity may limit the seasonal movements of the dwarf sawfish (Blaber *et al.*, 1989).

#### Age and Growth

While small compared to other sawfishes, the maximum size of dwarf sawfish has been reported as: 4 ft 11 in (1.5 m) TL (Grant, 1991), 4 ft 7 in (140 cm) TL (Last and Stevens, 1994; Rainboth, 1996; Compagno and Last, 1999), 10 ft (306 cm) TL (Peeverell, 2005), and 11.5 ft (350 cm) TL (Peeverell, 2005). Specimens from western Australia in 2008 indicate that females reach at least 10 ft 2 in (310 cm) TL (Morgan *et al.*, 2010a; Morgan *et al.*, 2011).

Thorburn *et al.* (2008) and Peeverell (2008) estimated age and growth for this species based on the number of vertebral rings and total length. The average growth estimates for dwarf sawfish are 16.1 in (41cm) TL in the first year, slowing to 9.4 in (24cm) in the second year (Peeverell 2008). Thorburn *et al.* (2008) determined that animals close to 3 ft (90 cm) TL were age 1, those between 3.5 and 4 ft (110 cm and 120 cm) TL were age 2, and those around 5 ft (160 cm) TL were age 6. Peeverell

(2008) reported dwarf sawfish between 2 ft 11 in and 3 ft 3 in (90 and 98 cm) TL were age 0, those between 3 ft 7 in and 5 ft 9 in (110–175 cm) TL were considered 1 to 3 years old, and those between 6 ft 7 in and 8 ft (201–244 cm) TL were considered 4 to 6 years old (Peeverell, 2008). Any dwarf sawfish over 9 ft 10 in (300 cm) TL is considered to be at least 9 years old (Morgan *et al.*, 2010a). The theoretical maximum age calculated from von Bertalanffy parameters for dwarf sawfish is 94 years (Peeverell, 2008).

#### Reproduction

There is little information available regarding the time or location of dwarf sawfish mating. It is hypothesized dwarf sawfish move into estuarine or fresh waters to breed during the wet season (Larson *et al.*, 2006), however no information on pupping habitat, gestation period, or litter size has been recorded (Morgan *et al.*, 2010a).

Dwarf sawfish are born between 2 ft 2 in and 2 ft 8 in (65 cm and 81 cm) TL (Morgan *et al.*, 2010a; Morgan *et al.*, 2011). Males become sexually mature between 9 ft 8 in and 10 ft (295 and 306 cm) TL with fully calcified claspers, though they may mature at smaller sizes, around 8 ft 5 in (255–260 cm) TL (Peeverell, 2005; Thorburn *et al.*, 2008; Last and Stevens, 2009; Morgan *et al.*, 2011). All males captured by Thorburn *et al.* (2008) less than 7 ft 5 in (226 cm) TL were immature; two females, both smaller than 3 ft 11 in (120 cm) TL, were also immature. There is little specific information about sexual maturation of females; females are considered immature at 6 ft 11 in (210 cm) TL (Peeverell, 2005; Peeverell, 2008; Morgan *et al.*, 2010a). Wueringer *et al.* (2009) indicates that neither males nor females are mature before 7 ft 8 in (233 cm) TL.

Intrinsic rates of population increase, based on life history data from Peeverell (2008), has been estimated to be about 0.10 per year (Moreno Iturria, 2012), with a population doubling time of 7.2 years.

#### Diet and Feeding

Dwarf sawfish, like other sawfishes, uses its saw to stun small schooling fishes. They may also use the saw for rooting in the mud and sand for crustaceans and mollusks (Breder Jr., 1952; Raje and Joshi, 2003; Larson *et al.*, 2006; Last and Stevens, 2009). In Western Australia, the dwarf sawfish eats shrimp, mullet, herring, and croaker (Thorburn *et al.*, 2008; Morgan *et al.*, 2010a).

#### Population Structure

Phillips *et al.* (2011) conducted a genetic study looking at mtDNA of dwarf sawfish and found no distinct difference in dwarf sawfish from the west coast of Australia and those from the Gulf of Carpentaria in northern Australia. The genetic diversity of this species was moderate overall; however, dwarf sawfish from the Gulf of Carpentaria may have a lower genetic diversity than those of the west coast, possibly due to either a small sample size or a reduction in abundance (Phillips *et al.*, 2008). Further declines in abundance as well as genetic drift may result in reduced genetic diversity (Morgan *et al.*, 2010a; Morgan *et al.*, 2011).

Later, Phillips *et al.* (2011), using additional samples determined the populations of the dwarf sawfish are organized matrilineally (from mother to daughter), indicating the possibility that females are philopatric (return to their birth place). Genetic analysis of dwarf sawfish on the northern coast of Australia determined that they were distinct from those in other areas (Phillips *et al.*, 2011). While the genetic diversity of this species is considered low to moderate across Australia, haplotype diversity in the Gulf of Carpentaria was very low but was greater in the west compared to the east. Low diversity among and within groups of dwarf sawfish may be detrimental (Phillips *et al.*, 2011).

#### Distribution and Abundance

Dwarf sawfish are thought to historically occur in the Indo-Pacific, western Pacific, and eastern Indian Oceans, with the population largely occurring in northern Australia (Last and Stevens, 1994; Last and Compagno, 2002; Compagno, 2002a; Compagno, 2002b; Thorburn *et al.*, 2008; Wueringer *et al.*, 2009; Morgan *et al.*, 2010a). While dwarf sawfish may have been historically more widespread throughout the Indo-West Pacific (Compagno and Last 1999, Last and Stevens, 2009), there are questions regarding records outside of Australian waters (DSEWPaC, 2011). In an effort to gather more information on the historic and current range and abundance, we conducted an extensive search of peer-reviewed publications and technical reports, newspaper, and magazine articles. A summary of those findings is presented below by major geographic region.

#### Indian Ocean

Dwarf sawfish are considered extremely rare in the Indian Ocean and

there are few records indicating its current presence (Last, 2002). Faria *et al.* (2013) report dwarf sawfish from the Indian Ocean: a female from the Reunion Islands, a female from an unidentified location in the Indian Ocean, and a male from India. There are no reports of dwarf sawfish from Sri Lanka in more than a decade, although they have been assumed to occur there (Last, 2002).

#### Indo-Pacific (excluding Australia)

Dwarf sawfish are considered very rare in Indonesia, with only a few records (Last, 2002). Faria *et al.* (2013) compiled most reports of dwarf sawfish in Indonesia; since the first record in 1894, there has been two rostral saws in 1910, and 5 other rostra without date or length information.

Although reported historically, dwarf sawfish have not been reported from most other areas in the Indo-Pacific in over a decade. The most recent report of a dwarf sawfish in Thailand was in the Mekong River Basin, Laos in 1996. No sawfish species, including the dwarf sawfish, were reported from the South China Sea from 1923–1996 (Compagno, 2002a).

#### Pacific Ocean

Very few reports of the dwarf sawfish have been recorded in the western Pacific Ocean. Deynat (2005) reported on two skin samples from a juvenile female found in Tasmanian waters, and Faria *et al.* (2013) reported on two additional specimens but no specifics were provided.

#### Australia

Australia likely represents the center of the range of dwarf sawfish. Dwarf sawfish have been reported from Cairns to the east through the Gulf of Carpentaria in the north and through Kimberley to the west (Compagno and Last, 1999, Last and Stevens, 2009).

Most records for dwarf sawfish are from the north and northwest areas of Australia. The earliest record of this species is from 1877 (Faria *et al.*, 2013). A single rostrum from a dwarf sawfish was found in 1916, but no other information was recorded. In 1946, a number of dwarf sawfish were reported (Faria *et al.*, 2013).

Most records over the last 30 years have been from north and northwest Australia. Five female and five male dwarf sawfish (32–55 in; 82–140 cm TL) were captured in 1990 in the Pentecost River using gillnets (Taniuchi and Shimizu, 1991; Taniuchi, 2002). Between 1994 and 2010, almost 75 tissue samples were taken from live dwarf sawfish or dried rostra from the

Gulf of Carpentaria and the northwest coast of Australia (Phillips *et al.*, 2011). In 1997, two specimens were collected near the mouth of Buffalo Creek in Darwin, Northern Territory (Chisholm and Whittington, 2000). In 2005, Naylor *et al.* (2005) collected one dwarf sawfish from Darwin, Australia. One dwarf sawfish was captured in 1998 in the upper reaches of the Keep River estuary (Larson, 1999; Gunn *et al.*, 2010). One interaction was reported between 2007 and 2010 by observers in the Northern Territory Offshore Net and Line Fishery (Davies, 2010). A single specimen from Queensland (eastern Australia) is preserved at the Harvard Museum of Comparative Zoology (Fowler, 1941).

In a comprehensive survey of the Gulf of Carpentaria from 2001–2002, Peverell (2005; 2008) indicated dwarf sawfish were concentrated in the western portion of the Gulf of Carpentaria; twelve males and ten females were captured. Most individuals caught in the inshore fishery were immature except for two mature males: 10 ft and 9 ft 8 in (306 cm and 296 cm) TL (Peverell, 2005; 2008).

In northwestern Australia within specific riverine basins, dwarf sawfish have been reported in various surveys. Forty-four dwarf sawfish were captured between October 2002 and July 2004 in the King Sound and the Robison, May, and Fitzroy Rivers (Thorburn *et al.*, 2008). Between 2001 and 2002, one dwarf sawfish was caught at the mouth of the Fitzroy River in western Australia (Morgan *et al.*, 2004). Morgan *et al.* (2011) acquired 109 rostra from dwarf sawfish from the King Sound area that were part of museum or personal collections.

In summary, there is some uncertainty in the species identification of historic records of dwarf sawfish, the intense fishing pressures within the range has likely caused the dwarf sawfish to become extirpated from much of the Indo-Pacific region and the species appears to be extirpated from eastern Australia. An October 2001 study on the effectiveness of turtle excluder devices in the prawn trawl fishery in Queensland, Australia, reported no dwarf sawfish (Courtney *et al.*, 2006). Dwarf sawfish are now considered rare in the Gulf of Carpentaria. It is likely the Kimberley territory and Pilbara region (western Australia) may be the last significant remaining areas for dwarf sawfish (P. Kyne pers. comm. to IUCN, 2012).

### Natural History of the Largetooth Sawfish (*Pristis pristis*)

#### Taxonomy and Morphology

Many have suggested classification of largetooth sawfish into a single circumtropical species given common morphological features of robust rostrum, origin of first dorsal fin anterior to origin of pelvic fins, and presence of a caudal-fin lower lobe (Günther, 1870; Garman, 1913; Fowler, 1936; Poll, 1951; Dingerkus, 1983; Daget, 1984; Séret and McEachran, 1986; McEachran and Fechhelm, 1998; Carvalho *et al.*, 2007). The recent analysis by Faria *et al.* (2013) used mtDNA and contemporary genetic analysis to argue the previously classified *P. pristis*, *P. microdon*, and *P. perotteti* should now be considered one species named *P. pristis*. After reviewing Faria *et al.* (2013) and consulting other sawfish experts we conclude, based on the best available information, that *P. pristis* applies to all the largetooth sawfishes previously identified as *P. pristis*, *P. microdon*, and *P. perotteti*. The largetooth sawfish has a robust rostrum, noticeably widening posteriorly (width between the two posterior-most rostral teeth is 1.7–2 times the width between the second anterior-most rostral teeth). Rostral teeth number is between 14 and 23 per side with grooves on the posterior margin. The body is robust with the origin of the first dorsal-fin anterior to the origin of the pelvic fin; dorsal fins are high and pointed with the height of the second dorsal fin greater than the first. The lower lobe of the caudal-fin is small but well-defined with the lower anterior margin about half as long as the upper anterior margin (Wallace, 1967; Taniuchi *et al.*, 1991a; Last and Stevens, 1994; Compagno and Last, 1999; Deynat, 2005; Wueringer *et al.*, 2009; Morgan *et al.*, 2010a; Morgan *et al.*, 2010b; Morgan *et al.*, 2011).

The largetooth sawfish has buccopharyngeal denticles and regularly overlapping monocuspidate dermal denticles on its skin. The denticles are present on both dorsal and ventral portions of the body (Wallace, 1967; Deynat, 2005). Within the mouth, there are between 70 and 72 tooth rows on the upper jaw, and 64–68 tooth rows on the lower jaw. The number of vertebrae is between 226 and 228 (Morgan *et al.*, 2010a). Coloration of the largetooth sawfish is a reddish brown dorsally and dull white ventrally (Fowler, 1941; Wallace, 1967; Compagno *et al.*, 1989; Taniuchi *et al.*, 1991a; Compagno and Last, 1999; Chidlow, 2007).

Male and female largetooth sawfish differ in the number of rostral teeth.

Using largetooth sawfish teeth collected from Papua New Guinea and Australia, Ishihara *et al.* (1991b) found males to have an average of 21 rostral teeth on the left and 22 on the right; females averaged 19 rostral teeth on both the left and the right side of the rostrum. Rostrum length can vary between males and females (Wueringer *et al.*, 2009).

#### Habitat Use and Migration

Largetooth sawfish are commonly found in coastal, inshore waters and are considered euryhaline (Compagno *et al.*, 1989; Last and Stevens, 1994; Compagno and Last, 1999; Chisholm and Whittington, 2000; Last, 2002; Compagno, 2002b; Peverell, 2005; Peverell, 2008; Wueringer *et al.*, 2009), being found in salinities ranging from 0 to 40 ppt (Thorburn *et al.*, 2007). The species has been found far upriver, often occupying freshwater lakes and pools; they are associated with freshwater more than any other sawfish species (Last and Stevens, 1994; Rainboth, 1996; Peter and Tan, 1997; Compagno and Last, 1999; Larson, 1999). Largetooth sawfish have even been observed in isolated fresh water billabongs or pools until floodwaters allow them to escape; juveniles often use these areas for multiple years as deep water refuges (Gorham, 2006; Thorburn *et al.*, 2007; Wueringer *et al.*, 2009; Morgan *et al.*, 2010b). Similarly, largetooth sawfish have been found in Lake Nicaragua in depths up to 400 ft (122 m) and are common in deeper holes, occupying muddy or sandy bottoms (NMFS, 2010a).

Adults more often utilize marine habitats than juveniles, and are typically found in waters with salinity at 31 ppt (Wueringer *et al.*, 2009). Despite the variety of habitats occupied, females have been found to be highly philopatric as indicated by mtDNA studies, while males often undergo long movements (Lack *et al.*, 2009; Phillips *et al.*, 2009; Morgan *et al.*, 2010a; Morgan *et al.*, 2010b; Morgan *et al.*, 2011). Within the Gulf of Mexico, America, mature largetooth sawfish have historically moved as far north as Texas (NMFS, 2010a).

The physical characteristics of habitat strongly influence the movements and areas utilized by largetooth sawfish. Recruitment of neonate largetooth sawfish was correlated with the rise in water levels during the wet season in Australia (Whitty *et al.*, 2009). A study of juvenile largetooth sawfish movements in the Fitzroy River in Australia found young-of-the-year utilize extremely shallow areas (0–1 ft 7 in or 0–0.49 m) up to 80 percent of the time, mostly to avoid predators

(Thorburn *et al.*, 2007). Juveniles and adult largemouth sawfish also utilize rivers (Compagno, 2002b; Gorham, 2006) and can be found in areas up to 248.5 miles (400 km) upstream (Chidlow, 2007). Activity space of largemouth sawfish increases with body length (Whitty *et al.*, 2009).

#### Age and Growth

There are several age and growth studies for the largemouth sawfish; results vary due to differences in aging techniques, data collection, or location. At birth, largemouth sawfish are between 2 ft 6 in and 3 ft (76 and 91 cm) TL, with females being slightly smaller than males on average (Chidlow, 2007; Morgan *et al.*, 2011). Thorson (1982) found pups at birth average 2 ft 4.7 in to 2 ft 7.5 in (73–80 cm) TL with a growth rate of 35–40 cm per year (NMFS, 2010a). Juveniles (age 1 to age at maturity) range in size from 2 ft 6 in to 9 ft (76 to 277 cm) TL (Morgan *et al.*, 2011).

Size at maturity is estimated to be around 9 ft 10 in (300 cm) TL for both sexes at around age 8 (Lack *et al.*, 2009; Morgan *et al.*, 2010a; Morgan *et al.*, 2010b; NMFS, 2010; Morgan *et al.*, 2011). Thorson (1982) estimated age of maturity to be 10 years at 9 ft 10 in (300 cm) TL in Lake Nicaragua (NMFS, 2010a). Generally, males under 7 ft 7 in (230 cm) TL and females under 8 ft 10 in (270 cm) TL are considered immature (Whitty *et al.*, 2009; Wueringer *et al.*, 2009).

The largest recorded length of a largemouth sawfish is 22 ft 11 in (700 cm) TL (Compagno *et al.*, 1989; Last and Stevens, 1994; Rainboth, 1996; Peter and Tan, 1997; Compagno and Last, 1999; Thorburn and Morgan, 2005; Compagno *et al.*, 2006b; Chidlow, 2007; NMFS, 2010a). The largest largemouth sawfish recorded in Kimberley, Queensland measured 21 ft 6 in (656 cm) TL (Morgan *et al.*, 2011). In other areas of Australia, the largemouth sawfish can reach up to 15 ft (457 cm) and at least 11 ft 10 in (361 cm) TL (Fowler, 1941; Chidlow, 2007; Gunn *et al.*, 2010).

Age and growth for largemouth sawfish has been estimated by Tanaka (1991) who generated a von Bertalanffy growth model for specimens collected from Papua New Guinea and Australia. For both sexes combined, the theoretical maximum size was calculated at 11 ft 11 in (363 cm) TL with a relative growth rate of 0.066 per year. Based on these calculations, it was determined that largemouth sawfish grow around 7 in (18 cm) in the first year and 4 in (10 cm) by the tenth year. Thorson (1982a) estimated an early juvenile growth rate of 13–15 in (35–40 cm) per year and

annual adult growth rate of 1 in (4.4 cm) per year based on largemouth from Lake Nicaragua. Peverell (2008) calculated a theoretical maximum size of 20 ft 11 in (638 cm) TL with a relative growth rate of 0.08 per year. The theoretical maximum age estimated for this species has been calculated to be 80 years (Morgan *et al.*, 2010a).

#### Reproduction

Largemouth sawfish are thought to reproduce in freshwater environments (Compagno and Last, 1999; Last, 2002; Compagno, 2002b; Martin, 2005; Thorburn and Morgan, 2005; Compagno *et al.*, 2006b) from May to July (Raje and Joshi, 2003). The number of pups in a largemouth sawfish litter varies by location, and possibly due to other factors. One of the earliest reproductive studies on largemouth sawfish by Thorson (1976a) indicated litter size ranged between 1 to 13 pups, with an average of 7 pups per cycle (NMFS, 2010a). Thorson (1976a) also found that both ovaries appeared to be functional, though the left seemed to be larger and carry more ova (NMFS, 2010a). Length of gestation for largemouth sawfish is approximately five months, with a biennial reproductive cycle (NMFS, 2010a). Chidlow (2007) reported largemouth sawfish had litters with up to 12 pups.

Intrinsic rates of population growth vary tremendously throughout the species range. Simpfendorfer (2000) estimated that the largemouth sawfish in Lake Nicaragua had an intrinsic rate of population growth of 0.05 to 0.07 per year, with a population doubling time of 10.3 to 13.6 years. Using data from Australia, rates of population increase were estimated to be around 0.12 per year (Moreno Iturria, 2012), with a population doubling time of approximately 5.8 years. Data from the western Atlantic Ocean indicate an intrinsic rate of increase of 0.03 per year, with a population doubling time of 23.3 years (Moreno Iturria, 2012).

#### Diet and Feeding

Largemouth sawfish diet is predominately fish, but varies depending on study and geographic area. Small fishes including seer fish, mackerels, ribbon fish, sciaenids, and pomfrets are likely main diet items of largemouth sawfish in the Indian Ocean (Devadoss, 1978; Rainboth, 1996; Raje and Joshi, 2003). Small sharks, mollusks, and crustaceans are also potential prey items (Devadoss, 1978; Rainboth, 1996; Raje and Joshi, 2003). Taniuchi *et al.*, (1991a) found small fishes and shrimp in the stomachs of juveniles in Lake Murray, Papua New

Guinea, while juvenile sawfish in western Australia had catfish, cherabin, mollusks, and insect parts in their stomachs (Thorburn *et al.*, 2007; Whitty *et al.*, 2009; Morgan *et al.*, 2010a). Largemouth sawfish have also been found to feed on catfish, shrimp, small crustaceans, croaker, and mollusks (Chidlow, 2007; Thorburn *et al.*, 2007; Morgan *et al.*, 2010a; Morgan *et al.*, 2010b). Largemouth sawfish captured off South Africa had bony fish and shellfish as common diet items (Compagno *et al.*, 1989; Compagno and Last, 1999). In general, largemouth sawfish subsist on the most abundant small schooling fishes in the area (NMFS, 2010a).

#### Population Structure

Genetic analyses based on a 480 base pair sequencing of the mtDNA gene NADH-2 sequence revealed information indicating largemouth sawfish subpopulations. Evidence of restricted gene flow has also been found with largemouth sawfish among these geographic areas: Atlantic and Indo-West Pacific; Atlantic and eastern Pacific; and Indo-West Pacific and eastern Pacific. Collectively a total of 19 haplotypes were identified across largemouth sawfish: one east Pacific haplotype; 12 western Atlantic haplotypes, two eastern Atlantic haplotypes; one Indian Ocean haplotype, one Vietnamese–New Guinean haplotype, and two Australian haplotypes (Faria *et al.*, 2013). This fine-scale structuring of sub-populations by haplotypes was only partially corroborated by the regional variation in the number of rostral teeth. While the rostral tooth count differed significantly in largemouth sawfish collected from the western and eastern Atlantic Ocean, it did not vary significantly between specimens collected from the Indian Ocean and western Pacific (Faria *et al.*, 2013). Largemouth sawfish collected from the western Atlantic specimens had a higher rostral teeth count than those collected from the eastern Atlantic. Data from separate protein and genetics studies indicates some evidence of distinction among sub-populations of largemouth sawfish in the Indo-Pacific. At a broad scale, Watabe (1991) found that there was limited genetic variability between samples taken from Australia and Papua New Guinea based on lactate dehydrogenase (LDH) isozyme patterns. Largemouth sawfish might be genetically subdivided within the Gulf of Carpentaria, Australia, with both eastern and western gulf populations (Lack *et al.*, 2009).

Phillips *et al.* (2011) found that the population of largemouth sawfish in the Gulf of Carpentaria is different from



animals on the west coast of Australia (Fitzroy River) based on mtDNA. Recent data (Phillips, 2012) suggests that matrilineal structuring is found at relatively small spatial scales within the Gulf of Carpentaria region (i.e., this region contains more than one maternal 'population'), although the precise location and nature of population boundaries are unknown. The difference in the genetic structuring using markers with different modes of inheritance (maternal versus bi-parental) suggests that largemouth sawfish may have male-biased dispersal and with females remaining at, or returning to, their birth place to mate (Phillips *et al.*, 2009, Phillips, 2012). Phillips (2012) noted that the presence of male gene flow between populations in Australian waters suggests that a decline of males in one location could affect the abundance and genetic diversity of assemblages in other locations.

The genetic diversity for largemouth sawfish throughout Australia seems to be low to moderate. Genetic diversity was greater in the Gulf of Carpentaria than in rivers in Australia, also suggesting potential philopatry (Lack *et al.*, 2009). However, given limited sampling, additional research is needed to better understand potential population structure of largemouth sawfish in Australia (Lack *et al.*, 2009; Phillips *et al.*, 2009; Morgan *et al.*, 2010a; Morgan *et al.*, 2010b).

#### *Distribution and Abundance*

Largemouth sawfish have the largest historic range of all sawfishes. The species historically occurred throughout the Indo-Pacific near southeast Asia and Australia and throughout the Indian Ocean to east Africa. Largemouth sawfish have also been noted in the eastern Pacific Ocean from Mexico to Ecuador (Cook *et al.*, 2005) or possibly Peru (Chirichigno and Cornejo, 2001). In the Atlantic Ocean, largemouth sawfish inhabit warm temperate to tropical marine waters from Brazil to the Gulf of Mexico in the western Atlantic, and Namibia to Mauritania in the eastern Atlantic (Burgess *et al.*, 2009). Older literature notes the presence of this species in Zanzibar, Madagascar, India, and the south-west Pacific (Fowler, 1941; Wallace, 1967; Taniuchi *et al.*, 2003).

Given the recent taxonomic changes for largemouth sawfish, we examined all current and historic records of *P. microdon*, *P. perotteti*, and *P. pristis* for a comprehensive overview on distribution and abundance. We conducted an extensive search of peer-reviewed publications and technical reports, newspaper, and magazine

articles. The result of that search is summarized below by major geographic region.

#### *Indian Ocean*

Largemouth sawfish historically occurred throughout the Indian Ocean; however current records are rare for many areas. The earliest record of largemouth sawfish was in 1936 from Grand Lac near the Gulf of Aden, Indian Ocean (Kottelat, 1985). A second record in 1936 is from Mangoky River, Madagascar (Taniuchi *et al.*, 2003).

Records from the 1960's and 1970's are largely from India and South Africa. One largemouth sawfish was reported from the confluence of the Lundi and Sabi Rivers, South Africa in 1960, over 200 miles inland (Jubb, 1967). Between 1964 and 1966, several largemouth sawfish were caught in the Zambesi River, South Africa during a general survey of rays and skates; they have also been recorded in the shark nets off Durban, South Africa (Wallace, 1967). In 1966, a male (10 ft; 305 cm TL) was captured in a trawl net in the Gulf of Mannar, Sri Lanka (Gunn *et al.*, 2010). Largemouth sawfish were commonly caught between 1973 and 1974 in the Bay of Bengal during the wet season (July and September) but rarely during other times of the year (Devadoss, 1978). Largemouth sawfish are also recorded in three major rivers that empty into the Bay of Bengal: the Pennaiyar, Paravanar, and Gadilam (Devadoss, 1978).

Current reports of largemouth sawfish throughout the Indian Ocean are isolated and rare. While the species could not be confirmed, a survey of fishing landing sites and interviews with 99 fishers in Kenya, Nyungi (unpublished report to J. Carlson, NMFS 2007), found 71 reports of sawfishes over the last 40 years. The longest time series of largemouth sawfish catches is from the protective beach nets off Natal, South Africa with a yearly average capture rate of 0.2 sawfish per 0.6 mi (1 km) net per year from 1981 to 1990; since then only two specimens have been caught in the last decade (CITES, 2007). Largemouth sawfish were reported in Cochin, India by the Central Marine Fisheries Research Institute in 1994, but no information about location, size or number of animals is available (Dan *et al.*, 1994). Commercial landings of elasmobranchs from 1981 to 2000 in the Bay of Bengal were mostly rays with some largemouth sawfish (Raje and Joshi, 2003). In the Betsiboka River, Madagascar, four largemouth sawfish were caught in 2001. The most recent capture of largemouth sawfish (18 ft; 550 cm TL) in India occurred on January 18,

2011, between Karnataka and Goa ([www.mangalorean.com](http://www.mangalorean.com)).

#### *Indo-Pacific Ocean (excluding Australia)*

Many islands within the Indo-Pacific region contain suitable habitat for largemouth sawfish, but few reports are available, perhaps due to the lack of surveys or data reporting. The earliest records of largemouth sawfish from the Indo-Pacific are from a compilation study of elasmobranchs in the waters off Thailand that reports a largemouth sawfish in the Chao Phraya River and its tributaries in 1945 (Vidthayanon, 2002). In 1955, two largemouth sawfish were captured from Lake Santani (present day Irian Jaya, Indonesia). Juvenile largemouth sawfish had also been reported around the same time in a freshwater river close to Genjem, Indonesia (Boeseman, 1956). In 1956, largemouth sawfish were recorded in Lake Sentani, New Guinea (Boeseman, 1956; Thorson *et al.*, 1966). However, in a study by Munro (1967) in the Laloki River in the southeastern portion of New Guinea, no sawfish were captured (Berra *et al.*, 1975). From 1967 to 1977, five largemouth sawfish were captured from the Indragiri River, Sumatra (Taniuchi, 2002). From 1970 to 1971, Berra *et al.* (1975) collected five largemouth sawfish from the Laloki River, Papua New Guinea.

More recently, 36 largemouth sawfish were captured in September 1989 in Papua New Guinea (Taniuchi and Shimizu, 1991; Taniuchi, 2002). In a survey of the Fly River system, Papua New Guinea, 23 individuals were captured in 1978 (Roberts, 1978; Taniuchi and Shimizu, 1991; Taniuchi *et al.*, 1991b; Taniuchi, 2002). The presence of largemouth sawfish in the Mahakam River, Borneo was recorded in 1987 (Christensen, 1992). Three largemouth sawfish rostra were acquired from local fish markets in Sabah in 1996 (Manjaji, 2002a) and survey indicate largemouth sawfish are still present in these areas, although locals have noticed a decline in their abundance (Manjaji, 2002a).

The scarcity of records from Indonesia led to an increased effort to document species presence (Fowler, 2002). Anecdotal evidence suggests that sawfishes have not been recorded in Indonesia for more than 25 years (White and Last, 2010). Largemouth sawfish have not been recorded in the Mekong River, Laos for decades (Rainboth, 1996). In a comprehensive study compiled by Compagno (2002a), no sawfishes were found in the south China Sea between the years of 1923 and 1996. Data from 200 survey days at fish landing sites in

eastern Indonesia between 2001 and 2005 recorded over 40,000 elasmobranchs, but only two largemouth sawfish (White and Dharmadi, 2007).

#### *Australian Waters*

Australia may have a higher abundance of largemouth sawfish than other areas within the species' current range (Thorburn and Morgan, 2005; Field *et al.*, 2009). Despite their current abundance levels, we only identified a few historic records from Australia. The first record of a largemouth sawfish was in 1945 in the Northern Territory (Stevens *et al.*, 2005). Faria *et al.* (2013) obtained a rostrum that was collected in Australia in 1960.

The most current reports of largemouth sawfish began in the 1980's. We found many more records of largemouth sawfish in Australia compared to other countries. A largemouth sawfish was captured from the Keep River, Australia in 1981 (Compagno and Last, 1999). Blaber *et al.* (1990) found that largemouth sawfish were among the top twenty-five most abundant species in the trawl fisheries of Albatross Bay from 1986 to 1988. Eight individuals were captured in the Leichhardt River in 2008 (Morgan *et al.*, 2010b). In a preliminary survey of the McArthur River, Northern Territory, Gorham (2006) reported two largemouth sawfish captured between 2002 and 2006. Surveys (Peeverell, 2005; Gill *et al.*, 2006; Peeverell, 2008) in the Gulf of Carpentaria found largemouth sawfish widely distributed throughout the eastern portion of the Gulf with most catches occurring near the mouth of many rivers (Mitchell, Gilbert, Archer, Nassau, Ord, and Staaten).

Juvenile largemouth sawfish in Australia use the Fitzroy River and other tributaries of the King Sound (Morgan *et al.*, 2004) as nursery areas while adults are found more often offshore (Morgan *et al.*, 2010a). Outside of the Fitzroy River and King Sound in western Australia, the only other areas where juvenile sawfish have been recently recorded are in Willie Creek and Roebuck Bay (Gill *et al.*, 2006; Morgan *et al.*, 2011). Nursery areas for largemouth sawfish are also reported in northern Australia in the Gulf of Carpentaria (Gorham, 2006). Despite the abundance of records from northern Australia, no sawfish have recently been captured within the Adelaide River, Australia, and abundance estimates from areas that have higher human populations may be declining (Taniuchi and Shimizu, 1991; Taniuchi *et al.*, 1991a; Morgan *et al.*, 2010a). Whitty *et al.* (2009) found that the population of juvenile largemouth sawfish in the Fitzroy River have declined in recent

years as catch per unit effort was 56.7 sawfish per 100 hours in 2003, compared to 12.4 in 2009. There were no reported captures of largemouth sawfish in 2008 from the Roper River system, which drains into the western Gulf of Carpentaria, Northern Territory (Dally and Larson, 2008). No adult sawfish were captured in any of the prawn trawl fisheries in Queensland, Australia during the month of October 2001 (Courtney *et al.*, 2006).

Outside the northern and western areas of Australia, largemouth sawfish do occur but reports are less frequent. In southwestern Australian waters, one female sawfish was captured by a commercial shark fisherman in February 2003, east of Cape Naturaliste (Chidlow, 2007). Data from the Queensland, Australia Shark Control Program shows a clear decline in sawfish catch over a 30 year period from the 1960's, and the complete disappearance of sawfish in southern regions by 1993 (Stevens *et al.*, 2005).

#### *Eastern Pacific*

In the eastern Pacific, the historic range of largemouth sawfish was from Mazatlan, Mexico to Guayaquil, Ecuador (Cook *et al.*, 2005) or possibly Peru (Chirichigno and Cornejo, 2001). There is very little information on the population status in this region and few reports of capture records. The species has been reported in freshwater in the Tuyra, Culebra, Tilapa, Chucunaque, Bayeno, and Rio Sambu Rivers, and at the Balboa and Miraflores locks in the Panama Canal, Panama; Rio San Juan, Colombia; and in the Rio Goasoran, along the border of El Salvador and Honduras (Fowler, 1936; 1941; Beebe and Tee-Van, 1941; Bigelow and Schroeder, 1953; Thorson *et al.*, 1966a; Dahl, 1971; Thorson, 1974; 1976; 1982a; 1982b, 1987; Compagno and Cook, 1995; all as cited in Cook *et al.*, 2005). The only recent reports of largemouth sawfish in this area are anecdotal reports from Columbia, Nicaragua, and Panama (R. Graham pers. comm. to IUCN, 2012).

#### *Western Atlantic Ocean*

In the western Atlantic Ocean, largemouth sawfish were widely distributed throughout the marine and estuarine waters in tropical and subtropical climates and historically found from Brazil through the Caribbean, Central America, the Gulf of Mexico, and seasonally into waters of the U.S. (Burgess *et al.*, 2009). Largemouth sawfish also occurred in freshwater habitats in Central and South America. Throughout the Caribbean Sea, the historical presence of the largemouth sawfish is uncertain and early records

might have been misidentified smallmouth sawfish (G. Burgess pers. comm. to IUCN, 2012).

Historic records of largemouth sawfish in the western north Atlantic have been previously reported in NMFS (2010a). Sawfish were documented in Central America in Nicaragua as early as 1529 by a Spanish chronicler (Gill and Bransford, 1877). This species was also historically reported in Nicaragua by Meek (1907), Regan (1908), Marden (1944), Bigelow and Schroeder (1953) and Hagberg (1968). Five largemouth sawfish were from a survey of Lake Izaba, Guatemala from 1946 to 1947, and sawfishes were reported to be important inland fisheries (Saunders *et al.*, 1950). The lone largemouth sawfish reported from Honduras was acquired from that country, but the true origin of the rostrum and the date of capture could not be confirmed (NMFS, 2010a).

In Atlantic drainages, largemouth sawfish were found in freshwater at least 833 miles (1,340 km) from the ocean in the Amazon River system (Manacapuru, Brazil), as well as in Lake Nicaragua and the San Juan River; the Rio Coco, on the border of Nicaragua and Honduras; Rio Patuca, Honduras; Lago de Izabal, Rio Motagua, and Rio Dulce, Guatemala; and the Belize River, Belize. Largemouth sawfish are found in Mexican streams that flow into the Gulf of Mexico; Las Lagunas Del Tortuguero, Rio Parismina, Rio Pacuare, and Rio Matina, Costa Rica; and the Rio San Juan and the Magdalena River, Colombia; (Thorson, 1974; 1982b; Castro-Augiree, 1978 as cited in Thorson, 1982b; Compagno and Cook, 1995; C. Scharpf and M. McDavitt, pers. comm., as cited in Cook *et al.*, 2005).

In the U.S., largemouth sawfish were reported in the Gulf of Mexico mainly along the Texas coast east into Florida waters, though nearly all records of largemouth sawfish encountered in U.S. waters were limited to the Texas coast (NMFS, 2010a). Though reported in the U.S., it appears that largemouth sawfish were never abundant, with approximately 39 confirmed records (33 in Texas) from 1910 through 1961.

The Amazon River basin and adjacent waters are traditionally the most abundant known range of largemouth sawfish in Brazil (Bates 1964; Marlier 1967; Furneau 1969). Most of the records for which location is known originated in the state of Amazonas, which encompasses the middle section of the Amazon River basin along with the confluence of the Rio Negro and Rio Solimoes Rivers. The other known locations are from the states of Rio Grande do Norte, Sergipe, Bahia, Espirito Santo, Rio de Janeiro, and Sao

Paulo, Para, and Maranhao (NMFS, 2010a). Most records of largemouth sawfish in the Amazon River (Amazonia) predate 1974. The Magdalena River estuary was the primary source for largemouth sawfish encounters in Colombia from the 1940's (Miles, 1945), while other records originated from the Bahia de Cartagena and Isla de Salamanca (both marine), and Rio Sinu (freshwater) from the 1960's through the 1980's (Dahl, 1964; 1971; Frank and Rodriguez, 1976; Alvarez and Blanco 1985). In other areas of South America, there are only single records from Guyana, French Guiana, and Trinidad from the late 1800's and early 1900's. Of the five records from Suriname, the most recent was 1962. Though thought to have once been abundant in some areas of Venezuela (Cervignon 1966a; 1966b), the most recent confirmed records of largemouth sawfish from that country was in 1962.

Many records in the 1970's and 1980's are largely due to Thorson's (1982a; 1982b) research on the Lake Nicaragua-Rio San Juan system in Nicaragua and Costa Rica. Bussing (2002) indicated that this species was known to inhabit the Rio Tempisque and tributaries of the San Juan basin in Costa Rica. Following Thorson's (1982a; 1982b) studies, records of largemouth sawfish in the western North Atlantic decline considerably. By 1981, Thorson (1982a) was unable to locate a single live specimen in the original areas he surveyed. There are no known Nicaraguan records of the largemouth sawfish outside of the Lake Nicaragua-Rio San Juan-Rio Colorado system (Burgess *et al.*, 2009), although largemouth sawfish are still captured incidentally by fishers netting for other species (McDavitt, 2002). Of the known largemouth sawfish reported from Mexico, most records are prior to 1978, and Caribbean records are very sparse (NMFS, 2010a). The last record of a largemouth sawfish in U.S. waters was in 1961 (Burgess *et al.*, 2009).

Most recent records for largemouth sawfish are in isolated areas. While many reports of largemouth sawfish from Brazil were from the 1980's and 1990's (Lessa, 1986; Martins-Juras *et al.*, 1987; Stride and Batista, 1992; Menni and Lessa, 1998; and Lessa *et al.*, 1999), recent records indicate largemouth sawfish primarily in fish markets at the Amazon-Orinoco estuaries (Charvet-Almeida, 2002; Burgess *et al.*, 2009). A Lake Nicaraguan fisherman reports he encounters a few sawfish annually (McDavitt, 2002). Other records are rare for the area. Three recent occurrences were found in Internet searches, one being a 200 lb. (90.7 kg) specimen

caught recreationally in Costa Rica (Burgess *et al.*, 2009). Though reported by Thorson *et al.* (1966a; 1966b) to be common throughout the area, there are no recent reports of encounters with sawfishes in Guatemala. Scientists in Columbia have not reported any sawfish sightings between 1999 and 2009 (Burgess *et al.*, 2009).

#### *Eastern Atlantic Ocean*

Historic records indicate that largemouth sawfish were once relatively common in the coastal estuaries along the west coast of Africa. Verified records exist from Senegal (1841–1902), Gambia (1885–1909), Guinea-Bissau (1912), Republic of Guinea (1965), Sierra Leone (date unknown), Liberia (1927), Cote d'Ivoire (1881–1923), Congo (1951–1958), Democratic Republic of the Congo (1951–1959), and Angola (1951). Most records, however, lacked species identification and locality data and may have been confused taxonomically with other species. Unpublished notes from a 1950's survey detail 12 largemouth sawfish from Mauritania, Senegal, Guinea, Cote d'Ivoire, and Nigeria, ranging in size from 35–275 in (89–700 cm) TL (Burgess *et al.*, 2009).

A more recent status review by Ballouard *et al.* (2006) reported that sawfishes, including the largemouth sawfish, were once common from Mauritania to the Republic of Guinea, but are now rarely captured or encountered. According to this report, the range of sawfishes has decreased to the Bissagos Archipelago (Guinea Bissau). The most recent sawfish encounters outside Guinea Bissau were in the 1990's in Mauritania, Senegal, Gambia, and the Republic of Guinea. The most recent documented largemouth sawfish capture was from 2005 in Nord de Caravela (Guinea Bissau), along with anecdotal accounts from fishers of captures off of two islands in the same area in 2008 (Burgess *et al.*, 2009).

In summary, on a global scale, largemouth sawfish appear to have been severely fragmented throughout their historic range into isolated populations of low abundance. Largemouth sawfish are now considered very rare in many places where evidence is available, including parts of east Africa, India, parts of the Indo-Pacific region, Central and South America and west Africa. Even within areas like Australia and Brazil, the species is primarily located in remote areas. Information from genetic studies indicates that largemouth sawfish display strong sex-biased dispersal patterns; with females exhibiting patterns of natal philopatry while males move more broadly between populations (Phillips *et al.*,

2011). Thus, the opportunity for re-establishment of these isolated populations is limited because any reduction in female abundance in one region is not likely to be replenished by migration from another region (Phillips, 2012).

#### **Natural History of Green Sawfish (*Pristis zijsron*)**

##### *Taxonomy and Morphology*

*Pristis zijsron* (Bleeker 1851) is frequently known as the narrow snout sawfish or the green sawfish. Synonymous names include *P. dubius* (Gloerfelt-Tarp and Kailola, 1984; Van Oijen *et al.*, 2007; Wueringer *et al.*, 2009). An alternative spelling for this species' scientific name (*P. zysron*) is found in older literature, due to either inconsistent writing or errors in translation or transcription (Van Oijen *et al.*, 2007).

The green sawfish has a slim saw with 25–32 small, slender rostral teeth; tooth count may vary geographically (Marichamy, 1969; Last and Stevens, 1994; Morgan *et al.*, 2010a). Specimens collected along the west coast of Australia have 24–30 left rostral teeth and 23–30 right rostral teeth (Morgan *et al.*, 2010a), although other reports are 23–34 (Morgan *et al.*, 2011). There have been no studies to determine sexual dimorphism from rostral tooth counts for green sawfish. The rostral teeth are generally denser near the base of the saw than at the apical part of the saw (Blegvad and Loppenthin, 1944). The total rostrum length is between 20.6–29.3 percent of the total length of the animal and may vary based on the number and size of individuals. In general, green sawfish have a greater rostrum length to total length ratio than other sawfish species (Morgan *et al.*, 2010a; Morgan *et al.*, 2011).

In terms of body morphology, the origin of the first dorsal fin on green sawfish is slightly posterior to the origin of pelvic fins. The lower caudal lobe is not well defined and there is no subterminal notch (Gloerfelt-Tarp and Kailola, 1984; Compagno *et al.*, 1989; Last and Stevens, 1994; Compagno and Last, 1999; Bonfil and Abdallah, 2004; Wueringer *et al.*, 2009; Morgan *et al.*, 2010a; Morgan *et al.*, 2011). The green sawfish has limited buccopharyngeal denticles and regularly overlapping monocuspidate dermal denticles on its skin. As a result, there are no keels or furrows formed on the skin (Deynat, 2005). The aptly named green sawfish is greenish brown dorsally and white ventrally. This species might be confused with the dwarf or smalltooth

sawfish due to its similar size and range (Compagno *et al.*, 2006c).

#### Habitat Use and Migration

The green sawfish mostly utilizes inshore, marine habitats, but it has been found in freshwater environments (Gloerfelt-Tarp and Kailola, 1984; Compagno *et al.*, 1989; Compagno, 2002b; Stevens *et al.*, 2008; Wueringer *et al.*, 2009). In the Gilbert and Walsh Rivers of Queensland, Australia, specimens have been captured as far as 149 miles (240 km) upriver (Grant, 1991). However, Morgan *et al.* (2010a; 2011) report green sawfish do not move into freshwater for any portion of its lifecycle. Like most sawfishes, the green sawfish prefers muddy bottoms in estuarine environments (Last, 2002). The maximum depth recorded for this species is 131 ft (40 m) but it is often found in much shallower waters, around 16 ft (5 m; Compagno and Last, 1999; Wueringer *et al.*, 2009). Adults tend to spend more time in offshore waters in Australia, as indicated by interactions with the offshore Pilbara Fish Trawl Fishery, while juveniles prefer protected, inshore waters (Morgan *et al.*, 2010a; Morgan *et al.*, 2011).

#### Age and Growth

At birth pups are between 2 ft and 2 ft 7 in (61 and 80 cm) TL. At age 1 green sawfish are generally around 4 ft 3 in (130 cm) TL (Morgan *et al.*, 2010a). Peverell (2008) found between age 1–5, green sawfish measure between 4 ft 2 in and 8 ft 5 in (128 and 257 cm) TL, based on the vertebral analysis of six individuals (Peverell, 2008; Morgan *et al.*, 2010a; Morgan *et al.*, 2011). A 12 ft 6 in (380 cm) TL green sawfish was found to be age 8, a 14 ft 4 in (438 cm) TL individual was found to be age 10, a 14 ft 9 in (449 cm) TL specimen was found to be age 16, and a 15 ft (482 cm) TL specimen was found to be age 18 (Peverell, 2008; Morgan *et al.*, 2011).

Adult green sawfish often reach 16 ft 5 in (5 m) TL, but may grow as large as 23 ft (7 m) TL (Compagno *et al.*, 1989; Grant, 1991; Last and Stevens, 1994; Compagno and Last, 1999; Bonfil and Abdallah, 2004; Compagno *et al.*, 2006c; Morgan *et al.*, 2010a). The largest green sawfish collected in Australia was estimated to be 19 ft 8 in (600 cm) TL based on a rostrum length of 5 ft 5 in (165.5 cm; Morgan *et al.*, 2010a; Morgan *et al.*, 2011).

Peverell (2008) completed an age and growth study for green sawfish using vertebral growth bands. Von Bertalanffy growth model parameters from both sexes combined resulted in estimated maximum theoretical size of 16 ft (482

cm) TL, relative growth rate of 0.12 per year and theoretical time at zero length of 1.12 yrs. The theoretical maximum age for this species is calculated to be 53 years (Peverell, 2008; Morgan *et al.*, 2010a).

#### Reproduction

Last and Stevens (2009) reported size at maturity for green sawfish at 9 ft 10 in (300 cm) TL, corresponding to age 9. In contrast, Peverell (2008) reported one mature individual of 12 ft 4 in (380 cm) TL and estimated its age as 9 yrs. Using the growth function from Peverell (2008) and assuming length of maturity at 118 in (300 cm), Moreno Iturria (2012) determined maturation is likely to occur at age 5. Demographic models based on life history data from the Gulf of Carpentaria indicate the generation time is 14.6 years, the intrinsic rate of population increase is 0.02 per year, and population doubling time is approximately 28 years (Moreno Iturria, 2012).

Green sawfish give birth to as many as 12 pups during the wet season (January through July; Last and Stevens, 1994; Peverell, 2008; Morgan *et al.*, 2010a; Morgan *et al.*, 2011). In Western Australia, females are known to pup in areas between One Arm Point and Whim Creek, with limited data for all other areas (Morgan *et al.*, 2010a; Morgan *et al.*, 2011). The Gulf of Carpentaria, Australia is also a known nursery area for green sawfish (Gorham, 2006). It is not known where the green sawfish breed or length of gestation.

#### Diet and Feeding

Like other sawfish, green sawfish use their rostra to stun small, schooling fishes, such as mullet, or use it to dig up benthic prey, including mollusks and crustaceans (Breder Jr., 1952; Rainboth, 1996; Raju and Joshi, 2003; Compagno *et al.*, 2006c; Last and Stevens, 2009). One specimen captured in 1967 in the Indian Ocean had jacks and razor fish (*Caranx* and *Centriscus*) species in its stomach (Marichamy, 1969). In Australia, the diet of this species often includes shrimp, croaker, salmon, glassfish, grunter, and ponyfish (Morgan *et al.*, 2010a).

#### Population Structure

Faria *et al.* (2013) found no global population structure for green sawfish in their genetic studies. However, geographical variation was found in the number of rostral teeth per side, suggesting some population structure may occur. Green sawfish from the Indian Ocean have a higher number of rostral teeth per side than those from

Western Pacific specimens (Faria *et al.*, 2013).

In Australia, genetic analysis found differences in green sawfish between the west coast, the east coast, and the Gulf of Carpentaria (Phillips *et al.*, 2011). Genetic data suggests these populations are structured matrilineally (from the mother to daughter) but there is no information on male genet flow at this time. These results may be indicative of philopatry where adult females return to or remain in the same area they were born (Morgan *et al.*, 2010a; Morgan *et al.*, 2011; Phillips *et al.*, 2011). Phillips *et al.* (2011) also found low levels of genetic diversity for green sawfish in the Gulf of Carpentaria, suggesting the population may have undergone a genetic bottleneck.

#### Distribution and Abundance

The green sawfish historically ranged throughout the Indo-West Pacific from South Africa northward along the east coast of Africa, through the Red Sea, Persian Gulf, southern Asia, Indo-Australian archipelago, and east to Asia as far north as Taiwan and southern China (Fowler, 1941; Blegvad and Løppenthin, 1944; Smith, 1945; Misra, 1969; Compagno *et al.*, 2002a and 2002b; Last and Stevens, 2009). Historic records indicating species presence are available from India, southeast Asia, Thailand, Malaysia, Indonesia, New South Wales, and Australia (Cavanagh *et al.*, 2003; Wueringer *et al.*, 2009; Morgan *et al.*, 2010a; Morgan *et al.*, 2011). Green sawfish have also been found in South Africa, the south China Sea, and the Persian Gulf (Fowler, 1941; Compagno *et al.*, 1989; Grant, 1991; Compagno and Last, 1999; Last, 2002; Compagno, 2002b; Morgan *et al.*, 2010a). To evaluate the current distribution and abundance of the green sawfish, we conducted an extensive search of peer-reviewed publications and technical reports, newspaper, and magazine articles. The results are summarized below by geographic area.

#### Indian Ocean

Green sawfish are widely distributed throughout the Indian Ocean with the first record in 1852 and several green sawfish were described near the Indian archipelago in the late 1800's (Van Oijen *et al.*, 2007). Additional historical records include one female specimen captured in the Red Sea near Dollfus in 1929. In Egypt, two green sawfish rostra were found in 1938 and an additional rostrum was found on Henjam Island, Gulf of Oman (Blegvad and Løppenthin, 1994).

Unconfirmed reports of green sawfish are available from the Andaman and

Nicobar Islands, India. In 1963, a male was captured at Port Blair, Gulf of Andaman (James, 1973). A female was captured in 1967 in the same area (Marichamy, 1969). One green sawfish was captured in the St. Lucia estuary, South Africa during a survey between 1975 and 1976 (Whitfield, 1999).

Despite historic records, there are few current records of green sawfish in the Indian Ocean. We presume green sawfish are extirpated in the Indian Ocean based on the lack of current records.

#### *Indo-Pacific Ocean (Excluding Australia)*

The first description of the green sawfish was based on a rostral saw (Bleeker, 1851) from Bandjarmasin, Borneo (Van Oijen *et al.*, 2007). A juvenile male was captured in Amboine, Indonesia in 1856 (Deynat, 2005). An isolated saw from the Gulf of Thailand was obtained in 1895 and estimated to be from a green sawfish 4 ft 8 in (143 cm) TL (Deynat, 2005). Eight specimens were sent to the Wistar Institute of Anatomy in 1898 from Baram, British North Borneo (Fowler, 1941).

Many islands within the Indo-Pacific region contain suitable habitat for sawfish but few records are available, possibly due to the lack of surveys or data reporting. Before 1995, there were few local scientific studies on the elasmobranchs, and only two species of freshwater ray had been recorded in Borneo. As a result, a great effort to document any unknown species was undertaken by Fowler (2002). Rostra and records were documented in the study, including several dried rostra of green sawfish from the Kinabatangan River area in the local markets of Sabah; no collection specifics were provided. Locals also indicated that this species could often be found in the Labuk Bay area (Manjaji, 2002a) and in the country's freshwater systems (Manjaji, 2002b), and reported a decline of sawfish overall.

Elsewhere in the Indo-Pacific region, few records of green sawfish have been reported. This species is currently considered endangered in Thailand by Vidthayanon (2002), and Compagno (2002a) reported no sawfish species from the south China Sea from 1923 through 1996. Anecdotal evidence suggests that sawfishes have not been recorded in Indonesia for more than 25 years (White and Last, 2010).

#### *Australia*

In Australian waters, records indicate green sawfish abundance is higher in the north compared to the south. The earliest record obtained was from the

Queensland Museum in 1929 indicating that green sawfish were found in Moreton Bay, Queensland (Fowler, 1941).

We found a paucity of records for green sawfish during the middle part of the last century. Reports of green sawfish occur again in the 1980's when two green sawfish were captured from Balgal, Queensland, Australia in 1985 (Beveridge and Campbell, 2005). One green sawfish was caught in the southern portion of the Gulf of Carpentaria in late 1990 during a fish fauna survey (Blaber *et al.*, 1994). Alexander (1991) captured a female green sawfish from the west coast of Australia that was used for a morphological study. Between 1994 and 2010, almost 50 tissue samples were taken from live green sawfish or dried rostra from multiple areas around Australia, primarily the Gulf of Carpentaria and northwest and northeast coasts (Phillips *et al.*, 2011). In 1997, one green sawfish was found at the mouth of Buffalo Creek near Darwin, Northern Territory, Australia (Chisholm and Whittington, 2000) and in a survey from 1999 through 2001 by White and Potter (2004) one green sawfish was captured in Shark Bay, Queensland. Peverell (2005; 2008) noted the green sawfish was the least encountered species in a survey from the Gulf of Carpentaria. In 2008, no green sawfish were captured from the Roper River system, which drains into the western Gulf of Carpentaria, Northern Territory, Australia (Dally and Larson, 2008). Some records have been reported for the east coast of Australia; one female green sawfish was acoustically tracked for 27 hours in May 2004 (Peverell and Pillans, 2004; Porteous, 2004).

In summary, the limited data makes it difficult to determine the current range and abundance of green sawfish. However, given the uniqueness (size and physical characteristics) of the sawfish, we believe the lack of records in the areas where the species was historically found likely indicates the species may no longer be present. In Australian waters, based on our review, all sawfish species have undergone significant declines. The southern extent of the range of green sawfishes in Australia has contracted (Harry *et al.*, 2011). Green sawfish have been reported as far south as Sydney, Australia, but are rarely found as far south as Townsville (Porteous, 2004). Green sawfish are currently found primarily along the northern coast of Australia.

Extensive surveys at fish landing sites throughout Indonesia since 2001 have failed to record the green sawfish (White pers. comm. to IUCN, 2012). There is

some evidence from the Persian Gulf and Red Sea (e.g., Sudan) of small but extant populations (A. Moore pers. comm. to IUCN, 2012). However, lack of data from surveys and commercial fisheries throughout much of the remainder of the range suggests that the abundance of green sawfish has declined significantly and it is currently at only a small fraction of its historic abundance.

#### **Natural History of the Non-listed Population(s) of Smalltooth Sawfish (*Pristis pectinata*)**

##### *Taxonomy and Morphology*

The smalltooth sawfish was first described as *Pristis pectinatus* (Latham, 1794). The name was changed to the currently valid *P. pectinata* to match gender of the genus and species.

The smalltooth sawfish has a thick body with a moderately sized rostrum. As with many other sawfishes, tooth count may vary by individual or region. While there is no reported difference in rostral tooth count between sexes, there have been reports of sexual dimorphism in tooth shape, with males having broader teeth than females (Wueringer *et al.*, 2009). Rostral teeth are denser near the apex of the saw than the base. Most studies report a rostral tooth count of 25 to 29 for smalltooth sawfish (Wueringer *et al.*, 2009). The saw may constitute up to one-fourth of the total body length (McEachran and De Carvalho, 2002).

The pectoral fins are broad and long with the origin of the first dorsal fin over or anterior to the origin of the pelvic fins (Faria *et al.*, 2013). The lower caudal lobe is not well defined and lacks a ventral lobe (Wallace, 1967; Gloerfelt-Tarp and Kailola, 1984; Last and Stevens, 1994; Compagno and Last, 1999; Bonfil and Abdallah, 2004; Wueringer *et al.*, 2009). This species has between 228 and 232 vertebrae (Wallace, 1967).

The smalltooth sawfish has buccopharyngeal denticles and regularly overlapping monocuspidate (single-pointed) dermal denticles on their skin. As a result, there are no keels or furrows formed on the skin (Last and Stevens, 1994; Deynat, 2005). The body is an olive grey color dorsally, with a white ventral surface (Compagno *et al.*, 1989; Last and Stevens, 1994; Compagno and Last, 1999). This species may be confused with narrow or green sawfish (Compagno, 2002b).

##### *Habitat Use and Migration*

All research on habitat use and migration has been conducted on the U.S. DPS of smalltooth sawfish. A

summary of recent information is found in NMFS (2010b), which indicates sawfish are generally found in shallow waters with varying salinity level that are associated with red mangroves. Juvenile sawfish also appear to have small home ranges and limited movements. Since NMFS (2010b), Simpfendorfer *et al.* (2011) reported electivity analysis on sawfish movements and demonstrated an affinity for salinities between 18 and at least 24 ppt, suggesting movements are likely made, in part, to remain within this salinity range. Therefore, freshwater flow may affect the location of individuals within an estuary. Poulakis *et al.* (2011) found juvenile smalltooth sawfish had an affinity for water less than 3 ft (1.0 m) deep, water temperatures greater than 30 degrees Celsius (86 degrees Fahrenheit), dissolved oxygen greater than 6 mg per liter, and salinity between 18 and 30 ppt. Greater catch rates for smalltooth sawfish less than 1 year old were associated with shoreline habitats with overhanging vegetation such as mangroves. Poulakis *et al.* (2012) further determined daily activity space of smalltooth sawfish is less than 1 mi (0.7 km) of river distance. Hollensead (2012) reported smalltooth sawfish activity areas ranged in size from 837 square yards to 240,000 square yards to approximately 3 million square yards (0.0007 to 2.59 km<sup>2</sup>) with average range of movements of 7 ft to 20 ft (2.4 to 6.1 m) per minute. Hollensead (2012) also found no difference in activity area or range of movement between ebb and flood, or high and low tide. Activity area decreased and range of movement increased at night, indicating possible nocturnal foraging. Using a combination of data from pop-off archival transmitting tags across multiple institutional programs, movements and habitat use of adult smalltooth sawfish were determined in southern Florida and the Bahamas (Carlson *et al.*, in review). All smalltooth sawfish generally remained in coastal waters at shallow depths (96 percent of their time at depths less than 32 ft; 10 m) and warm water temperatures (22–28 degrees Celsius (71.6–82.4 degrees Fahrenheit) within the region where they were initially tagged, travelling an average of 49 mi (80.2 km) from deployment to pop-off location on an average of 95 days. No smalltooth sawfish tagged within U.S. or Bahamian waters have been tracked to countries outside where they were tagged.

#### Age and Growth

There is no age and growth data for smalltooth sawfish outside of the U.S.

DPS. A summary of age and growth data on the U.S. DPS of smalltooth sawfish is found in NMFS (2010b) indicates rapid juvenile growth for smalltooth sawfish for the first 2 years after birth. Recently, Scharer *et al.* (2012) counted bands on sectioned vertebrae from naturally deceased smalltooth sawfish and estimated von Bertalanffy growth parameters. Theoretical maximum size was estimated at 14.7 ft (4.48 m), relative growth was 0.219 per year, with theoretical maximum size at 15.8 years.

#### Reproduction

Outside U.S. waters, smalltooth sawfish have been recorded breeding in Richard's Bay and St. Lucia, South Africa (Wallace, 1967; Compagno *et al.*, 1989; Compagno and Last, 1999). Pupping grounds are usually inshore, in marine or freshwater, and pupping occurs year around in the tropics, but in only spring and summer at higher latitudes (Compagno and Last, 1999). Records of captive breeding have been reported from the Atlantis Paradise Island Resort Aquarium in Nassau, Bahamas; copulatory behavior was observed in 2003 and 6 months later the female aborted the pups for unknown reasons (McDavitt, 2006). In October 2012, a female sawfish gave birth to five live pups (J. Choromanski, pers. comm.).

Several studies have examined demography of smalltooth sawfish in U.S. waters. Moreno Iturria (2012) calculated demographic parameters for smalltooth sawfish in U.S. waters and estimated intrinsic rates of increase at 7 percent annually with a population doubling time of 9.7 years. However, preliminary results of a different model by Carlson *et al.* (2012) indicates population increase rates may be greater, up to 17.6 percent annually, for the U.S. population of smalltooth sawfish. It is not clear which of these models is more appropriate for the non-U.S. populations of smalltooth sawfish.

#### Diet and Feeding

Smalltooth sawfish often use their rostrum saw in a side-sweeping motion to stun its prey, which may include small fishes, or dig up invertebrates from the bottom (Breder Jr., 1952; Compagno *et al.*, 1989; Rainboth, 1996; McEachran and De Carvalho, 2002; Raje and Joshi, 2003; Last and Stevens, 2009; Wueringer *et al.*, 2009).

#### Population Structure

A qualitative examination of genetic (NADH-2) sequences revealed no geographical structuring of smalltooth sawfish haplotypes (Faria *et al.*, 2013). However, variation in the number of rostral teeth number per side was found

in specimens from the western and eastern Atlantic Ocean (Faria *et al.*, 2013).

#### Distribution and Abundance

Outside U.S. waters, smalltooth sawfish were thought to be historically found in South Africa, Madagascar, the Red Sea, Arabia, India, the Philippines, along the coast of west Africa, portions of South America including Brazil, Ecuador, the Caribbean Sea, the Mexican Gulf of Mexico, as well as Bermuda (Bigelow and Scheroder, 1953; Wallace, 1967; Van der Elst, 1981; Compagno *et al.*, 1989; Last and Stevens, 1994; IUCN, 1996; Compagno and Last, 1999; McEachran and De Carvalho, 2002; Monte-Luna *et al.*, 2009; Wueringer *et al.*, 2009). However, reports of smalltooth sawfish from other than the Atlantic Ocean are likely misidentifications of other sawfish (Faria *et al.*, 2013). In the eastern Atlantic Ocean, smalltooth sawfish were historically found along the west coast of Africa from Angola to Mauritania (Faria *et al.*, 2013). Although smalltooth sawfish were included in historic faunal lists of species found in the Mediterranean Sea (Serena, 2005), it is still unclear if smalltooth sawfish occurred as part of the Mediterranean ichthyofauna or were only seasonal migrants.

To evaluate the current and historic distribution and abundance of the smalltooth sawfish outside the U.S. DPS, we conducted an extensive search of peer-reviewed publications and technical reports, newspaper, and magazine articles. The result of that search is summarized below by major geographic region.

#### Eastern Atlantic Ocean

Smalltooth sawfish were once common in waters off west Africa, but are now rarely reported or documented in the area. The earliest record of smalltooth sawfish in Africa was in 1907 from Cameroon: seven records for five males and two females. Female specimens were recorded in the Republic of the Congo in 1911 and 1948. Other reports from the Republic of Congo include a male and two females, but dates were not recorded. A female specimen from Mauritania was recorded but no date is given (Faria *et al.*, 2013). A rostra from the Republic of the Congo, Pointe Noire, Molez was found in 1958 as well as a record of a large female from Somalia in 1909 (Deynat, 2005; Faria *et al.*, 2013). There are records of smalltooth sawfish from Senegal as early as 1956 and another rostral saw was recorded in 1959. Faria *et al.* (2013) also reports on four other rostra from

Senegal, but no specific information is available.

In the 1970s, records of smalltooth sawfish became limited to more northern areas of west Africa. One rostral saw from Senegal was recorded in 1975 (Alexander, 1991). Similarly, one rostral saw was reported from Gambia in 1977, but information about exact location or sex of the animal was absent (Faria *et al.*, 2013). Faria *et al.* (2013) report a record of smalltooth sawfish in Guinea Bissau in 1983 and a record of a saw in 1987. For a morphological study, Deynat (2005) obtained a juvenile female from Port-Etienne, Mauritania, in 1986, and another from Cacheu, Guinea-Bissau in 1983. Two rostra were reported from the Republic of Guinea: one in 1980 and one in 1988 (Faria *et al.*, 2013).

In the last 10 years, there has been only one confirmed record of a smalltooth sawfish outside of U.S. waters in Sierra Leone, west Africa, in 2003 (M. Diop, pers. comm.). Two other countries have recently reported sawfish (Guinea Bissau, Africa in 2011, and Mauritania in 2010) but these reports did not specify them as smalltooth sawfish.

#### *Western Atlantic Ocean (Outside U.S. Waters)*

Overall, records of smalltooth sawfish in the western Atlantic Ocean are scarce and show a non-continuous range, potentially due to misidentification with largetooth sawfish. Faria *et al.* (2013) summarized most records of smalltooth sawfish in these areas as described below. The earliest records are a female smalltooth sawfish from Haiti in 1831 and a female sawfish from Trinidad and Tobago in 1876. Another early record of two smalltooth sawfish saws is from Guyana in 1886 and an additional saw was later recorded in 1900. In Brazil, there is a 1910 report of a female smalltooth sawfish.

In the middle part of the 20th century there are reports of two female smalltooth sawfish from Mexico in 1926. Rostral saws were found in Suriname in 1943, 1944 and 1963, but no additional location or biotic information is known. Similarly, one rostrum was reported from Costa Rica in 1960, one rostral saw from Trinidad and Tobago in 1944, and in 1958 and 1960, several whole individuals and one rostrum were recorded from Guyana. There are also several other undated specimens recorded from Guyana from this period.

There are other records of smalltooth sawfish's presence in the western Atlantic Ocean but specific information is lacking. For example, Faria *et al.*,

(2013) reports that four rostral saws came from Mexico and two from Belize. One female was reported from Venezuela and two saws from Trinidad and Tobago.

In conclusion, while records are sparse, it is likely the distribution of smalltooth sawfish in the Atlantic Ocean is patchy and has been reduced in a pattern similar to largetooth sawfish. Data suggests only a few viable populations might exist outside the U.S. Due to better quality of habitat and low urbanization, some areas in the Caribbean Sea may have a greater number of smalltooth sawfish than other areas. For example, smalltooth sawfish have been repeatedly reported along the western coast of Andros Island, Bahamas (R.D. Grubbs pers. comm., 2010) and The Nature Conservancy noted two smalltooth sawfish at the northern and southern end of the island in 2006. Fishing guides commonly encounter smalltooth sawfish around Andros Island while fishing for bonefish and tarpon (R.D. Grubbs pers. comm., 2010), and researchers tagged two in 2010 (Carlson *et al.*, in review). In Bimini, Bahamas, generally one smalltooth sawfish has been caught every two years as part of shark surveys conducted by the Bimini Biological Station (D. Chapman pers. comm.). In west Africa, Guinea Bissau represents the last areas where sawfish can be found (M. Diop pers. comm. to IUCN, 2012). Anecdotal reports indicate smalltooth sawfish may also be found in localized areas off Honduras, Belize, and Cuba (R. Graham pers. comm. to IUCN, 2012).

#### **Species Determinations**

We first consider whether or not the narrow sawfish (*A. cuspidata*), dwarf sawfish (*P. clavata*), largetooth sawfish (*P. pristis*), green sawfish (*P. zijsron*), and all non-listed population(s) of smalltooth sawfish (*P. pectinata*) meet the definition of "species" pursuant to section 3 of the ESA. Then we consider if any populations meet the DPS criteria.

#### *Consideration as a "Species" Under the Endangered Species Act*

Based on the best available scientific and commercial information described above in the natural history sections for each species, we have determined that the narrow sawfish (*A. cuspidata*), dwarf sawfish (*P. clavata*), largetooth sawfish (*P. pristis*), and green sawfish (*P. zijsron*) are taxonomically-distinct species and therefore eligible for listing under the ESA.

#### *Distinct Population Segments*

In order to determine if any populations segments of the above species, and especially the petitioned and currently non-listed population segment of smalltooth sawfish (*P. pectinata*), constitutes a "species" eligible for listing under the ESA, we used the natural history information and our joint NMFS- USFWS Policy regarding the recognition of distinct population segments (DPS) under the ESA (61 FR 4722; February 7, 1996). We examined the three criteria that must be met for a DPS to be listed under the ESA: (1) The discreteness of the population segment in relation to the remainder of the species to which it belongs; (2) the significance of the population segment to the remainder of the species to which it belongs; and (3) the population segment's conservation status in relation to the Act's standards for listing (i.e., is the population segment, when treated as if it were a species, endangered or threatened?).

A population may be considered discrete, if it satisfies one on the following conditions: (1) It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors; or (2) it is delimited by international governmental boundaries within which differences of control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the ESA.

We looked for information indicating that population segments of narrow sawfish (*A. cuspidata*); dwarf sawfish (*P. clavata*); largetooth sawfish (*P. pristis*); green sawfish (*P. zijsron*) were markedly separate from other populations. There are few data available to examine physical, physiological, ecological, or behavioral distinctiveness of these sawfish. The morphology, ecology, and physiology of a sawfish likely limits extensive transoceanic movements; however local migrations are likely and limited movement data exists among larger individuals (Carlson *et al.*, in review). Phillips *et al.* (2011) noted the presence of matrilineal structuring of narrow sawfish (*A. cuspidata*), dwarf sawfish (*P. clavata*), and green sawfish (*P. zijsron*), suggesting the presence of either barriers to dispersal or some aspect of adult behavior limiting the effective dispersal of at least the female component of populations. Information on the population structure of the largetooth sawfish (*P. pristis*) indicates restricted gene flow between the

Atlantic and Indo-West Pacific; Atlantic and Eastern Pacific; and Indo-West Pacific and Eastern Pacific (Faria *et al.*, 2013). Fine-scale structuring of subpopulations was only partially collaborated by the regional variation in the number of rostral teeth (Faria *et al.*, 2013).

The genetic diversity for largemouth sawfish across Australia seems to be low to moderate. More genetic diversity was found in the Gulf of Carpentaria than in specific Australian Rivers, indicative of potential philopatry (Lack *et al.*, 2009). However, data are limited and more samples are required to fully realize any population structure of largemouth sawfish (Lack *et al.*, 2009; Phillips *et al.*, 2009; Morgan *et al.*, 2010a; Morgan *et al.*, 2010b).

Genetic studies of narrow sawfish have also been completed to evaluate the population structure of the species. Field *et al.* (2009) used genetic samples of narrow sawfish and found distinctions in the isotopic content of their rostral teeth, indicating differences within samples from the eastern and western portions of the Gulf of Carpentaria. The techniques used by Field *et al.* (2009) are still in its infancy and it is not clear whether or not these results are typically concordant with the parallel genetic studies of population structure. Isotopic signatures provide information on the location where the animal spends most of its time, and does not necessarily provide information on the reproductive connectivity between various regions.

Although some studies report geographic variation in rostral tooth counts and some matrilineal structuring, we conclude that the best available information indicates individuals of narrow sawfish (*A. cuspidata*), dwarf sawfish (*P. clavata*), green sawfish (*P. zijson*), and largemouth sawfish (*P. pristis*), are not markedly separated from the remainder of the species and therefore are not discrete as defined by the DPS policy. Largemouth sawfish under their original taxonomic classification (i.e., 3 separate species) might have geographically separate populations (e.g., western North Atlantic, eastern Pacific, and Indo-Pacific Ocean), but we cannot conclude any population meets the DPS criteria of discreteness given the lack of supporting biological information. Therefore, we will examine the global status of narrow sawfish, dwarf sawfish, largemouth sawfish, and green sawfish in our evaluation for endangered or threatened status.

We previously determined that the U.S. DPS of smalltooth sawfish was discrete (68 FR 15674; April 1, 2003), as

no information was available to indicate smalltooth sawfish in U.S. waters interact with those in international waters or other countries. The joint DPS policy states that the agency may consider a population discrete because it “is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.” In 2003, we concluded that the U.S. population of smalltooth sawfish is effectively isolated and listed it as endangered along international governmental boundaries (68 FR 15674; April 1, 2003).

We now evaluate the non-U.S. populations of smalltooth sawfish to determine if they meet the discreteness criteria of the joint DPS policy. First, we determine the non-U.S. populations of smalltooth sawfish are discrete from the U.S. population because they are delimited by international governmental boundaries within which differences of control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the ESA. Because we have designated critical habitat for the U.S. DPS population of smalltooth sawfish, there is a regulatory mechanism for protecting juvenile smalltooth sawfish and their habitats in the U.S. that does not exist for the non-U.S. populations of smalltooth sawfish. Movement data from smalltooth sawfish tagged in U.S. and Bahamian waters also indicate no movement to countries outside where they were tagged. This information supports the DPS discreteness criterion of being markedly separate as a consequence of ecological factors. However, we have no information indicating genetic differences exist between the smalltooth sawfishes throughout their range outside U.S. waters or other biological information that would provide a strong basis for further separating the non-U.S. smalltooth sawfish population into smaller units. We, therefore, conclude that the non-U.S. populations of smalltooth sawfish meet the discreteness criterion of the joint DPS policy and we consider these populations as a single potential DPS.

After meeting the discreteness criterion in the DPS policy, we then considered whether the non-U.S. population of smalltooth sawfish meets the significance criterion. The joint DPS policy gives examples of potential considerations indicating the population's significance to the larger taxon. Among these considerations is

evidence that the discrete population segment would result in a significant gap in the range of the taxon. Smalltooth sawfish are limited in their distribution outside of the U.S. to west Africa, the Caribbean, Mexico, and Central and South America. Loss of this group of smalltooth sawfish would result in a significant gap in the range of this species and restrict distribution to U.S. waters. Because the loss of smalltooth sawfish in areas outside the U.S. would result in a significant gap in the range of the species, we conclude the non-U.S. population of smalltooth sawfish is significant as defined by the DPS policy. We also note that no difference in status of the species is found among all areas.

Based on the above analysis of discreteness and significance, we conclude that the non-U.S. population of smalltooth sawfish (*P. pectinata*) meets the definition of a DPS and is eligible for listing under the ESA, and hereafter refer to it as the non-U.S. DPS of smalltooth sawfish.

#### Extinction Risk

We next consider the risk of extinction for narrow sawfish, dwarf sawfish, green sawfish, largemouth sawfish, and the non-U.S. DPS of smalltooth sawfish to determine whether the species are threatened or endangered per the ESA definition. We used the methods developed by Wainwright and Kope (1999) to organize and summarize our findings. This approach has been used in the review of many other species (Pacific salmonid, Pacific hake, walleye pollock, Pacific cod, Puget Sound rockfishes, Pacific herring, and black abalone) to summarize the status of the species according to demographic risk criteria. The methods developed by Wainwright and Kope (1999) further consider the risk to small populations based on potential genetic effects or random demographic effects, and considered habitat capacity to answer questions about the carrying capacity and whether or not the carrying capacity can ensure the populations viability. Using these concepts, we estimated the extinction risk for each of the five species at both current and anticipated risks expected in the foreseeable future. We also performed a threats assessment by identifying the severity of threats that exist now and in the foreseeable future. We defined the “foreseeable future” as the timeframe over which threats, or the species response to those threats, can be reliably predicted to impact the biological status of the species. We determined that the foreseeable future is approximately three generation times, calculated for each of the species based



on the demographic calculations of Moreno Iturria (2012): narrow sawfish, 14 years; dwarf sawfish, 49 years; largetooth sawfish, 48 years; green sawfish, 38 years; and the non-U.S. DPS of smalltooth sawfish, 30 years. After considering the life history of the each species, availability of data, and type of threats, we concluded that 3 generations was an appropriate measure to evaluate threats in the foreseeable future. As a late-maturing species, with slow growth rate and low productivity, it would take more than one generation for any conservation management action to be realized and reflected in population abundance indices. The timeframe of 3 generations is a widely used scientific indicator of biological status, and has been applied to decision making models by many other conservation management organizations, including the American Fisheries Society, the CITES, and the IUCN.

Wainwright and Kope (1999) used trends in abundance, productivity, and genetic variability to examine short and long-term trends in abundance as the primary indicators of risk. Wainwright and Kope (1999) also considered genetic integrity (introduced genotypes, interactions with hatchery fish, or anthropogenic selection) and connectivity to assess genetic diversity and take into account the potential for genetic exchange. Populations that are more fragmented have less genetic exchange and therefore less connectivity, which increases the risk of extinction. Loss of fitness and loss of diversity can occur from random genetic effects and increase the risk of extinction for a species. The last factor that Wainwright and Kope (1999) evaluated is the risks associated with recent events. Changes in harvest rates or natural events (floods, volcanic eruptions) can pose a risk for species but may not have been adequately considered by looking at the other effects above when there is a time-lag in seeing the effect of recent events. Given the global distribution of these sawfishes, coupled with limited data on catch rates, we did not include these additional factors in our extinction risk analysis.

We consider four categories to assess extinction risk of each sawfish species: (1) Abundance, (2) growth rate/productivity, (3) genetic integrity which includes the connectivity and genetic diversity of the species, and (4) spatial structure/connectivity. We determined extinction risk for each category for both now and in the foreseeable future using a five level qualitative scale to describe our assessment of the risk of extinction. At the lowest level, a factor, either alone

or in combination with other factors, is considered “unlikely” to significantly contribute to risk of extinction for a species. The next lowest level is considered to be a “low” risk to contribute to the extinction risk, but could contribute in combination with other factors. The next level is considered a “moderate” risk of extinction for the species, but in combination with other factors contributes significantly to the risk of extinction. A ranking of “likely” means that factor by itself is likely to contribute significantly to the risk of extinction. Finally, the most threatening factors are considered “highly likely” to contribute significantly to the risk of extinction.

We ranked abundance as likely or highly likely to contribute significantly to the current and foreseeable risk of extinction for all sawfishes. It appears the northern coast of Australia supports the largest remaining groups of dwarf, largetooth, green, and narrow sawfish in the Pacific and Indian Ocean, with some isolated groups in the western and central Indo-Pacific region, where the latter three species occur. Smalltooth sawfish are still being reported outside of U.S. waters in the Caribbean Sea, but records are few and mostly insular (e.g., Andros Island) where habitat is available and gillnet fisheries are not a threat to the species (see below). There are only four records of largetooth sawfish in the eastern Atlantic Ocean over the last decade. Similarly, recent largetooth sawfish records in the western Atlantic are from only the Amazon River basin and the Rio Colorado-Rio San Juan area in Nicaragua. We considered the current levels of abundance and realize many areas where sawfish still occur are subject to commercial and artisanal fisheries and potential habitat loss, and therefore rank the risk of extinction due to low abundance as high into the foreseeable future.

Wainwright and Kope (1999) stated short- and long-term trends in abundance are a primary indicator of extinction risk and may be calculated from a variety of quantitative data such as research surveys, commercial logbook or observer data, and landings information when accompanied by effort. Similar to information relative to abundance, we found that the natural history information indicates an absence of long-term monitoring data for all five sawfishes. We looked for inferences about extinctions risk of species based on the trends in past observations using the presence of a particular species at specified places and times (e.g., Dulvy *et al.*, 2003; Rivadeneira *et al.*, 2009).

The available museum records, negative scientific survey results, and anecdotal reports indicate the abundance trend for all five sawfishes is declining and population sizes are small. Information available on the species’ distribution also indicates the populations are significantly reduced.

We next considered that sawfish have historically been classified as having both low reproductive productivity and low recovery potential. We looked to the demography of smalltooth and largetooth sawfish from the northwest Atlantic Ocean that was originally investigated using an age-structured life table (Simpfendorfer, 2000). Using known estimates of growth, mortality, and reproduction at the time, Simpfendorfer (2000) determined that intrinsic rates of population increase ranged from 8–13 percent per year, and population doubling times were approximately 5 to 8.5 years for both species. These estimates included assumptions that there was no fishing mortality, no habitat limitations, no population fragmentation, or other effects of small population sizes. Simpfendorfer (2006) further modeled the demography of smalltooth sawfish using a method for estimating the rebound potential of a population by assuming that maximum sustainable yield was achieved when the total mortality was twice that of natural mortality (Au and Smith, 1997). This demographic model produced intrinsic rates of population increase that were from 2–7 percent per year for both smalltooth and largetooth sawfish. These values are similar to those calculated by Smith *et al.* (2008) using the same methodology corresponding to elasmobranch species with the lowest productivity (Smith *et al.*, 2008). Musick *et al.* (2000) noted that species with intrinsic rates of increase of less than 10 percent were particularly vulnerable to rapid population declines and a higher risk of extinction.

Some recent studies on the life history of sawfish, however, indicate they are potentially more productive than originally proposed. Growth rates (von Bertalanffy “K”) for some species, like narrow sawfish, approach 0.34 per year (Peverell, 2008). Data from tag-recapture studies and analysis of vertebral growth bands from smalltooth sawfish indicates that the first few years after birth represent the time when growth is most rapid (e.g., Simpfendorfer *et al.*, 2008; Scharer *et al.*, 2012). Using updated life history information, Moreno Iturria (2012) calculated intrinsic rates of increase for these five species of sawfish and determined values ranging from a low of 0.03 per year for largetooth

sawfish to a high of 0.27 per year for narrow sawfish. Considering this information, and the inferred declining trend in abundance, we conclude productivity was a moderate risk for the narrow sawfish but a high risk for the other four species. We also determined that productivity would remain a moderate risk for the narrow sawfish and a high risk for the other four species, in the foreseeable future.

We also combined consideration of the two categories including genetic diversity, spatial structure, and connectivity of each species as it relates to the genetic integrity. Population structure and levels of genetic diversity have recently been assessed for the green sawfish, dwarf sawfish, and largemouth sawfish across northern Australia using a portion of the mtDNA control region. Phillips *et al.* (2011) found statistically significant genetic structure within species and moderate genetic diversity among these species. These results suggest that sawfish may be more vulnerable to local extirpation along certain parts of their range, especially in areas where the population has been fragmented and movement between these areas is limited. However, these results do not necessarily suggest a higher risk of extinction throughout the entire range of the species. Chapman *et al.* (2011) investigated the genetic diversity of the U.S. DPS of smalltooth sawfish that has declined to between one to five percent of its abundance in the 1900's, while its core distribution has contracted to less than 10 percent of its former range (NMFS, 2009). Unexpectedly, the U.S. DPS of smalltooth sawfish exhibited no genetic bottleneck and has genetic diversity that is similar to other, less depleted elasmobranch populations (Chapman *et al.*, 2011). Given that all species of sawfish have suffered similar abundance declines, we believe this conclusion should serve as a surrogate for the other sawfish species. Because the U.S. DPS of smalltooth sawfish has not undergone a genetic bottleneck, we ranked genetic integrity as a moderate risk for all sawfish species as it is likely in combination with other factors to contribute significantly to the risk of extinction. However, we determined that the risk of extinction due to the lack of connectivity was high for all five species, primarily because all populations have undergone severe fragmentation. While genetic results provide optimism for the remaining populations of sawfish, this does not preclude the promotion of management actions to enhance connectivity among populations that have been historically

fragmented. We are also somewhat optimistic that sawfish populations may begin to rebuild in some areas and the risk of connectivity was determined to decrease for smalltooth and the narrow sawfish in the foreseeable future, although by only a small amount.

After reviewing the best available scientific data and the extinction risk evaluation on the 5 species of sawfishes, we conclude the risk of extinction for all five species of sawfish is high now and in the foreseeable future.

#### **Summary of Factors Affecting the Five Species of Sawfishes**

Next we consider whether any of the five factors specified in section 4(a)(1) of the ESA are contributing to the extinction risk of these five sawfishes.

##### *The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range*

We identified habitat destruction, modification, or curtailment of habitat or range as a potential threat to all five species of sawfishes and determined this factor is currently, and in the foreseeable future, contributing significantly to the risk of extinction of these species.

##### **Coastal and Riverine Habitats**

Loss of habitat is one of the factors determined to be associated with the decline of smalltooth sawfish in the U.S. (NMFS, 2009). As juveniles, sawfishes rely on shallow nearshore environments, primarily mangrove-fringed estuaries as nurseries (e.g., Wiley and Simpfendorfer, 2010; Norton *et al.*, 2012). Coastal development and urbanization have caused these habitats to be reduced or removed from many areas throughout the species' historic and current range. Habitat loss was identified as one of the most serious threats to the persistence of all species of sawfish, posing high risks for extinction. It is still unclear how anthropogenic impacts to habitats affect the recruitment of juvenile sawfish, and therefore adequate protection of remaining natural areas is essential. Given the threat from coastal urbanization coupled with the predicted reduction of mangroves globally (Alongi, 2008), we believe the risk of habitat loss would significantly contribute to both the decline of sawfish and their reduced viability.

We expect habitat modification throughout the range of these sawfishes to continue with human population increases. As humans continue to develop rural areas, habitat for other species, like sawfish, becomes compromised (Compagno, 2002b).

Habitat modification affects all five species of sawfish, especially those inshore, coastal habitats near estuaries and marshes (Compagno and Last, 1999; Cavanagh *et al.*, 2003; Martin, 2005; Chin *et al.*, 2010; NMFS, 2010). Mining and mangrove deforestation severely alter the coast habitats of estuaries and wetlands that support sawfish (Vidhayanon, 2002; Polhemus *et al.*, 2004; Martin, 2005). In addition, riverine systems throughout most of these species' historical range have been altered or dammed. For example, the potential expansion of the McArthur River Mine would permanently realign channels that would in turn affect the number of pools formed during the wet and dry seasons, many of which are used as refuge areas for dwarf, green, or largemouth sawfish (Polhemus *et al.*, 2004; Gorham, 2006).

While the status of habitats across the global range of these sawfishes is not well known, we expect the continued development and human population growth to have negative effects on habitat, especially to nearshore nursery habitats. For example, Ruiz-Luna *et al.* (2008) acknowledge that deforestation of mangrove forests in Mexico has occurred from logging practices, construction of harbors, tourism, and aquaculture activities. Valiela *et al.* (2001) reported on mangrove declines worldwide. They showed that the area of mangrove habitat in Brazil decreased by almost half (9652 to 5173 square miles) from 1983–1997, with similar trends in Guinea-Bissau (1837 to 959 square miles) from 1953–1995. The areas with the most rapid mangrove declines in the Americas included Venezuela, Mexico, Panama, the U.S., and Brazil. Along the western coast of Africa, the largest declines have occurred in Senegal, Gambia, Sierra Leone, and Guinea-Bissau. World-wide mangrove habitat loss was estimated at 35 percent from 1980–2000 (Valiela *et al.*, 2001). These areas where mangroves are known to have decreased are within both the historic and current ranges of these five species.

##### **Hydroelectric and Flood Control Dams**

Hydroelectric and flood control dams pose a major threat to freshwater inflow into the euryhaline habitats of sawfishes. Alterations of flow, physical barriers, and increased water temperature affect water quality and quantity in the rivers, as well as adjacent estuaries that are important nursery areas for sawfish. Regulating water flow affects the environmental cues of monsoonal rains and increased freshwater flow for pupping (Peverell, 2008; Morgan *et al.*, 2011). Increases in

siltation due to regulated water flow may also affect benthic habitat or prey abundance for these sawfishes (Compagno, 2002; Polhemus *et al.*, 2004; Martin, 2005; Thorburn *et al.*, 2007; Chin *et al.*, 2010; Morgan *et al.*, 2010a).

New dams being proposed to provide additional irrigation to farmland upstream may affect sawfish habitat. For example, the Gilbert River, in Queensland, Australia drains into the Gulf of Carpentaria which is the nursery area for green, dwarf, and largemouth sawfish. Further modification of the McArthur and Gilbert Rivers, along with increased commercial fishing in coastal waters, will negatively affect sawfishes by reducing available habitat while increasing bycatch mortality (Gorham, 2006).

### Water Quality

Largemouth sawfish in particular, and likely the other sawfishes, have experienced a loss of habitat throughout their range due to the decline in water quality. Agriculture and logging practices increase runoff, change salinity, and reduce the flow of water into freshwater rivers and streams that affects the habitat of the largemouth sawfish (Polhemus *et al.*, 2004; IUCN Red List, 2006); mining seems to be the most detrimental activity to water quality. Pollution from industrial waste, urban and rural sewage, fertilizers and pesticides, and tourist development all end up in these freshwater systems and eventually the oceans. Pollution from these operations, as well as cyanide spills (Papua-New Guinea, 1996), has caused a reduction in the number of sawfish in these freshwater systems (Vidthayanon, 2002; Polhemus *et al.*, 2004).

In summary, habitat alterations that potentially affect sawfishes include commercial and residential development, construction of water control structures, and modification to freshwater inflows. All sawfishes are vulnerable to a host of habitat impacts because they use rivers, estuaries, bays, and the ocean at various times of their life cycle. Based on our review of current literature, scientific survey and anecdotal information on the historic and current distribution, we find that destruction, modification, and curtailment of habitat or ranges is a factor affecting the status of each species, and we conclude that this factor is contributing, on its own or in combination with other factors, to the extinction risk of all five species of sawfishes.

### *Overutilization for Commercial, Recreational, Scientific, or Educational Purposes*

We identified overutilization for commercial, recreational, scientific, or educational purposes as a potential threat to all five species of sawfishes and determined that it is currently and in the foreseeable future contributing significantly to their risk of extinction.

### Commercial Fisheries

Commercial fisheries pose the biggest threat to these sawfishes, as these species are bycatch from many fisheries. Their unusual morphology and prominent saw makes sawfishes particularly vulnerable to most types of fishing gear, most notably any type of net (Anak, 2002; Hart, 2002; Last, 2002; Pogonoski *et al.*, 2002; Cavanagh *et al.*, 2003; Porteous, 2004; Gorham, 2006; IUCN Red List, 2006; Chidlow, 2007; Field, 2009; Chin *et al.*, 2010; NMFS, 2010; Morgan *et al.*, 2011). Trawling gear is of particular concern as it is the most common gear used within the range and habitat of sawfishes (Compagno and Last, 1999; Taniuchi, 2002; Walden and Nou, 2008). In Thailand, for example, all sawfish fins obtained and sold to markets are a result of bycatch by otter-board trawling and gillnet fisheries as there are no directed sawfish fisheries in the country (Pauly, 1988; Vidthayanon, 2002). The Lake Nicaragua commercial fishery for largemouth sawfish that collapsed prior to the 1980's was comprised mostly of gillnet boats (Thorson 1982a), and the commercial small coastal shark fishery in Brazil mainly utilizes gillnets and some handlines (Charvet-Almeida, 2002). Subadult and adult smalltooth sawfish have been reported as bycatch in the U.S. Gulf of Mexico and south Atlantic shrimp trawl fishery (NMFS SEFSC, 2011). However, if proper techniques are used, all sawfish species, particularly adults, are fairly resilient and can be released alive from most fishing gear (Lack *et al.*, 2009).

While the occasional live release from commercial fishing gear does occur, sawfishes are often retained. The meat is generally consumed locally, but the fins and rostra are of high value and sold in markets where these products are unregulated (CITES, 2007). In Brazil a captured sawfish is most likely retained because of the value of their products, as the rostra, teeth, and fins are valued at upwards of \$1,000 U.S. in foreign markets (NMFS, 2010a). The proportion of largemouth sawfish in these markets is unknown, although as many as 180 largemouth sawfish saws were annually sold at a single market in

northern Brazil in the early 2000's (McDavitt and Charvet-Almeida, 2004). The Trade Records Analysis of Flora and Fauna in Commerce (TRAFFIC) organization found that meat, liver oil, fins, and skin are among the most preferred sawfish products in Asian markets (Anak, 2002; Vidthayanon, 2002). In the Gulf of Thailand, over 5,291 US tons (4,800 tonnes) of rays were caught annually from 1976–1989; at the same time over 1,102 US tons (1,000 tonnes) of rays were caught in the Andaman Sea (Vidthayanon, 2002). It is likely that most of these products were sold in Asian markets because of the high demand for sawfish products. Reports of sawfish products in various markets throughout Asia are often inconsistent and inaccurate despite international rules on take and possession of sawfish products (Fowler, 2002; Clarke *et al.*, 2008; Kiessling *et al.*, 2009).

Recreational or commercial fishing gear may be abandoned or lost at sea. These “ghost” nets are an entanglement hazard for sawfishes and have become an increasing problem in the Gulf of Carpentaria where over 5,500 “ghost nets” were removed in 2009. Sawfish captures are expected to occur in regions where no quantitative information about “ghost nets” exists (Gunn *et al.*, 2010).

Misidentification, general species-composition grouping, and failure to record information are all concerns for reporting sawfish captures in direct or indirect commercial fisheries (Stobutzki *et al.*, 2002b). With little enforcement of regional and international laws, the practice of landing sawfishes may continue (NMFS, 2010a). All sawfish populations have been declining worldwide, partly due to the negative effects of commercial fishing (Stevens *et al.*, 2000; Peverell, 2008).

### Recreational Fisheries

Sawfish are bycatch of many recreational fisheries throughout their range, even in areas where they are protected, including many Australian rivers (Walden and Nou, 2008; Field *et al.*, 2009). Peverell (2008) reports that some sawfish are a target sport fish for recreational fishermen in the Gulf of Carpentaria, Queensland. Historic information from the U.S. indicates that recreational hook and line fishers in Texas sometimes target large sharks as trophy fish but may capture sawfish (Burgess *et al.*, 2009). Elsewhere in the U.S., the abundance of sawfishes is low and likely never high enough for recreational fishers to encounter sawfish, much less target it (NMFS, 2010a). With the increase in human

population along the coast, recreational fishing has the potential to put additional pressure on sawfish species that utilize coastal habitats (Walden and Nou, 2008).

### Indigenous Take

Due to the large populations of various indigenous people throughout the range of these five species, and the lack of data on the animals they harvest, the number of sawfish taken by local peoples is unknown. Elasmobranchs are caught for consumption throughout the Indo-Pacific. In some areas the meat and fins of these animals is of high market value and are sold rather than consumed. Due to this unregulated consumption, removal of elasmobranchs, which includes sawfishes, is a serious threat (Compagno and Last, 1999; Pogonoski *et al.*, 2002; Vidthayanon, 2002; Thorburn *et al.*, 2007; Peverell, 2008; Morgan *et al.*, 2010a).

Some studies have been conducted on the use and value of elasmobranch parts to various indigenous groups, particularly those in eastern Sabah, Indonesia. One study (Almada-Villela, 2002) found the majority of natives from Pulau Tetabuan and Pulau Mabul only take what is necessary for subsistence. Sawfish rostra are also valued and kept as decoration or given as gifts at the expense of the animal (Almada-Villela, 2002; McDavitt *et al.*, 1996; Vidthayanon, 2002).

### Protective Coastal Nets

The use of protective gillnets to prevent shark attacks on humans is great in some areas but can have a negative impact due to bycatch. Sawfishes are highly susceptible to nets because of their saws that are easily tangled in the nets. In Africa, the first protective gillnets lined the southeast tip of the continent's coast as early as 1952. By 1990, over 44 km of nets lined the area between Richards Bay and Mzamba (Dudley and Cliff, 1993). In these nets specifically, about 350 sharks and rays were captured between 1981 and 1990. A high percentage of entangled sawfish are released alive because of their ability to breathe while motionless. Dudley and Cliff (1993) reported 100 percent and 67 percent of largetooth and smalltooth sawfish caught during that time were released alive. However, subsequent mortality post-release due to stress or injury from the process is unknown and potentially detrimental given other fishing pressures (Dudley and Cliff, 1993).

### Scientific and Educational Uses

Because of their unique morphology, sawfishes are in high demand by aquariums throughout the world for display (McDavitt *et al.*, 1996). Removal of these animals from their natural habitats has caused some concern for these sawfish species and their ecosystems. The animals removed from the wild could be adult females and would not be available for reproduction (Anak, 2002; Harsan and Petrescu-Mag, 2008). No information is available on the level of mortality that occurs during the capture and transporting of live sawfish to aquaria.

Worldwide, we are not aware of any narrow sawfish in captivity (Peverell, 2005; 2008). We are aware of two dwarf sawfish held in captivity in Japan (McDavitt, 2006). Largetooth sawfish are the most common sawfish species in captivity (NMFS, 2010a). Juvenile largetooth are most often caught for the aquaria trade, measuring less than 3.5 ft (1 m) TL on average (Peter and Tan, 1997). We are aware of over 45 individual largetooth sawfish in captivity globally.

Globally, scientists are collecting information on sawfish biology. Research efforts began in 2003, on the U.S. DPS population of smalltooth sawfish and no negative impacts have been found due to that research.

While no quantitative data on fishery impacts are available, we conclude that given the susceptibility of sawfish to entanglement in predominant fishing gear (nets) throughout their range, that sawfishes are likely captured as incidental take as we are not aware of any fisheries specifically targeting sawfishes. This impact from fisheries is the most likely cause of the range contraction and presumed low number in many areas of their former range. There are few data available describing the trade of sawfish parts, however we are aware sawfish parts are often sold on Internet sites such as eBay. The use of sawfish teeth as cockfighting spurs and the sale of meat and fins for consumption continue. Therefore we conclude the overutilization for commercial and recreational purposes, alone or in combination with other factors as discussed herein, is contributing significantly to the risk of extinction of the narrow, dwarf, largetooth, green, and the non-U.S. DPS of smalltooth sawfish.

### Disease and Predation

We determine disease and predation are not potential threats to any of the five species of sawfish and that it is unlikely that this factor, on its own or

in combination with other factors is, currently or in the foreseeable future contributing significantly to their risk of extinction.

Although sympatric with other sawfishes and large sharks, we are not aware of any studies or information documenting interspecific competition in terms of either habitat or prey (NMFS, 2010a). Thorson (1971) speculated that the Lake Nicaragua bull shark population may compete with the sawfishes, as both were quite prevalent, but he offered no additional data. Sawfishes have been documented within the stomach of a dolphin near Bermuda (Bigelow and Schroeder, 1953; Monte-Luna *et al.*, 2009), in the stomach of a bull shark in Australia (Thorburn *et al.*, 2004), and a juvenile smalltooth sawfish was captured in the U.S. with fresh bite marks from what appeared to be a bull shark (T. Wiley-Lescher, pers. comm.). The International Union for Conservation of Nature (IUCN) Red List states that crocodiles prey on sawfishes (Cook, S.F. & Compagno, L.J.V. 2005).

Scientific data does not exist on diseases that may affect sawfishes, but there are reports of a smalltooth sawfish found dead during a red tide event on the west coast of Florida (International Sawfish Encounter Database, 2009). There is no evidence that unusual levels of disease or predation on their own, or in combination with other factors, pose an extinction risk to any of these sawfishes.

### Inadequacy of Existing Regulatory Mechanisms

We identified inadequacy of existing regulatory mechanisms as a potential threat to each of the five species of sawfish. We determined that this factor alone, or in combination with other factors, is currently, and in the foreseeable future, contributing significantly to their risk of extinction.

While the use of turtle exclusion devices (TEDs) in the nets of trawl fisheries to conserve sea turtles occurs throughout the range of sawfishes, TEDs are not efficient in directing sawfish out of nets because sawfish rostra get entangled (Stobutzki *et al.*, 2002a; Brewer *et al.*, 2006) prior to reaching the TED. TEDs are often used when trawling occurs along the sea bottom or at depths of 49 ft to 131 ft (15 to 40 m), both areas where sawfish are likely to be found (Stobutzki *et al.*, 2002a). Most sawfishes show no difference in recovery after going through a trawl net, regardless of the presence or absence of a TED (Griffiths, 2006). Stobutzki *et al.* (2002a) found that large females are more likely to survive after passing through a trawling net compared to smaller males.

Only narrow sawfish were found to benefit from the presence of TEDs in nets as 73.3 percent escaped (Brewer *et al.*, 2006; Griffiths, 2006). In general, TEDs tend to have negligible or a negative impact on sawfish that get captured by trawling nets (Stobutzki *et al.*, 2002a; Griffiths, 2006), but they do provide an escape route if the animal does not get entangled.

While the international organizations including the Trade Records Analysis of Flora and Fauna in Commerce (TRAFFIC), the Food and Agricultural Organization (FAO), the International Council for the Exploration of the Sea (ICES), and the International Commission for the Conservation of Atlantic Tuna (ICCAT) work to develop global networks to monitor wildlife trade, there is no consistent reporting of the trade in elasmobranchs (Clarke *et al.*, 2008; Lack and Sant, 2011) perhaps due to their lower commercial value compared to bony fish (Holmes *et al.*, 2009). Data reporting is often inconsistent among these groups, customs agencies and national fisheries (Anak, 2002). Reports are often vague and include general descriptions like “shark fin” or “ray,” lending practically no information of trading rates of specific products (Lack and Sant, 2011). Other countries in the Indo-Pacific do not report bycatch statistics or elasmobranchs taken illegally (Holmes *et al.*, 2009). In order for effective management plans to be implemented in fin markets and for sawfish product trade, data need to be consistent.

Many countries in the Indo-Pacific and the Middle East do not have formal legislation for management or national protection of the sawfish that may occur in their waters. Presently, Thailand has no protective legislation for any elasmobranch in the country, only some regulated fisheries (Vidthayanon, 2002). Thailand recently (1995) banned export of marine species for aquaria (Vidthayanon, 2002). Despite efforts by the International Plan of Action for the Conservation and Management of Sharks (IPOA Shark Plan) requiring all Gulf of Oman countries to have a shark conservation plan by 2001, none have been developed as of 2010. Iran has no regulations regarding fin removal, but they do limit the shark fishing season in the Gulf of Oman (Moore, 2011). The countries in Africa face similar circumstances as enforcement for sawfish protection is unknown (NMFS, 2010a). Those countries that do have protective legislation are often taken advantage of by foreign vessels because no punishment results. In one study, DNA barcoding was used to identify fins from the green sawfish confiscated from

foreign boats illegally fishing in northern Australian waters (Holmes, 2009).

While it appears that several organizations are trying to regulate and manage sawfish, many have proven to be inadequate. Illegal exploitation by foreign fishers often occurs when regulations exist but are not enforced (KieSSLing *et al.*, 2009). Preventative measures on existing fishing mechanisms to avoid sawfish catch, international monitoring of trade and governmental influence on fisheries are not presently sufficient to protect sawfishes. Specific regulation and monitoring of sawfishes by country would provide better protection (Vidthayanon, 2002; Walden and Nou, 2008). Therefore we conclude the inadequacy of existing regulatory mechanisms has and continues to significantly contribute to the risk of extinction of the narrow, dwarf, largetooth, green, and the non-U.S. DPS of smalltooth sawfish.

#### *Other Natural or Manmade Factors Affecting its Continued Existence*

We do not have information to determine that other natural or manmade factors are potential threats to any of the five species of sawfishes and conclude it is unlikely that this factor, on its own or in combination with other factors, is currently or in the foreseeable future contributing significantly to the risk of extinction.

An increase in global sea-surface temperature and sea level may already be influencing sawfish populations (Clark, 2006; Walden and Nou, 2008; Chin *et al.*, 2010). Fish assemblages are likely to change their distribution and could affect the prey base for sawfishes. Estuaries, including sawfish pupping grounds, may be affected as climate change changes patterns in freshwater flow due to rainfall and droughts. Skewed salinities in these areas or extreme tide levels might discourage adults from making up-river migrations (Clark, 2006). Saltwater marsh grass and mangrove areas play important roles in sawfish habitat as well (Simpfendorfer *et al.*, 2010); any disruption to these areas may affect sawfish populations. While many scientists can agree on the presence of climate change, few can agree on the effects that climate change will have on sawfish and their environments specifically (Clark, 2006; Chin *et al.*, 2010).

Red tide is the common name for a harmful algal bloom (HAB) of marine algae (*Karenia brevis*) that can make the ocean appear red or brown. *Karenia brevis* is one of the first species ever reported to have caused a HAB and is

principally distributed throughout the Gulf of Mexico, with occasional red tides in the mid- and south-Atlantic U.S. *Karenia brevis* naturally produces a brevetoxin that is absorbed directly across the gill membranes of fish or through ingestion of algal cells. While many HAB species are nontoxic to humans or small mammals, they can have significant effects on aquatic organisms. Fish mortalities associated with *K. brevis* events are very common and widespread. The mortalities affect hundreds of species during various stages of development. Red tide toxins can cause intoxication in fish, which may include violent twisting and corkscrew swimming, defecation and regurgitation, pectoral fin paralysis, caudal fin curvature, loss of equilibrium, quiescence, vasodilation, and convulsions, culminating in death. However, it is known that fish can die at lower cell concentrations and can also apparently survive in much higher concentrations. In some instances, mortality from red tide is not acute but may occur over a period of days or weeks of exposure to subacute toxin concentrations. There is no specific information on red tide effects to sawfish, but a report exists of a smalltooth sawfish that was found dead along the west coast of Florida, during a red tide event (National Sawfish Encounter Database, 2009). Therefore, we conclude red tide can affect all sawfish species (NMFS, 2010a).

Sawfishes have slow growth rates, late maturity, a long life span, and low fecundity rates which make them K-selected animals. K-selected animals can compete successfully in predictable or stable environments. K-selected characteristics do not enable them to respond rapidly to additional sources of mortality, such as overexploitation and habitat degradation. Collectively these other natural or manmade factors may be affecting the continued existence of the narrow, dwarf, largetooth, green, and the non-U.S. DPS of smalltooth sawfish. However, we are uncertain on the importance of these threats and additional studies are needed to determine the importance of other manmade and natural factors to the long-term survival of all five species of sawfishes.

#### **Overall Risk Summary**

After considering the extinction risks for each of the five species of sawfish, we have determined the narrow, dwarf, largetooth, green, and the non-U.S. DPS of smalltooth sawfish are in danger of extinction throughout all of their ranges due to (1) Present or threatened destruction, modification or curtailment

of habitat, (2) overutilization for commercial, recreational, scientific, or educational purposes, and (3) inadequacy of existing regulatory mechanisms.

### Protective Efforts

Section 4(b)(1)(A) of the ESA requires the Secretary, when making a listing determination for a species, to take into consideration those efforts, if any, being made by any State or foreign nation to protect the species. In judging the efficacy of not yet implemented efforts, or those existing protective efforts that are not yet fully effective, we rely on the Services' joint "Policy for Evaluation of Conservation Efforts When Making Listing Decisions" ("PECE"; 68 FR 15100; March 28, 2003). The PECE policy is designed to ensure consistent and adequate evaluation on whether any conservation efforts that have been recently adopted or implemented, but not yet proven to be successful, will result in recovering the species to the point at which listing is not warranted or contribute to forming the basis for listing a species as threatened rather than endangered. The PECE policy is expected to facilitate the development of conservation efforts by states and other entities that sufficiently improve a species' status so as to make listing the species as threatened or endangered unnecessary.

The PECE policy establishes two basic criteria to use in evaluating efforts identified in conservations plans, conservation agreements, management plans or similar documents: (1) the certainty that the conservation efforts will be implemented; and (2) the certainty that the efforts will be effective. We evaluated conservation efforts to protect and recover sawfish that are either underway but not yet fully implemented, or are only planned.

All sawfishes in the family Pristidae were listed on Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) at the 14th Conference of the Parties meeting in 2007. An Appendix I listing bans all commercial trade in parts or derivatives of sawfish with trade in specimens of these species permitted only in exceptional circumstances (e.g., for research purposes). An annotation to the Appendix I listing allows the largemouth sawfish *P. microdon* (herein *P. pristis*) to be treated as Appendix II "for the exclusive purpose of allowing international trade in live animals to appropriate and acceptable aquaria for primarily conservation purposes." The annotation was accepted on the basis that Australian populations of *P.*

*microdon* are robust relative to other populations in the species' range; and that the capture of individuals for aquaria is not likely to be detrimental to the population. At the CITES 16th Annual Conference of the Parties (COP) in March of 2013 Australia's proposal to transfer *P. microdon* from Appendix II to Appendix I was adopted. While the recent banning of all trade of largemouth sawfish has the potential to reduce the number of live animals removed for aquaria trade, the potential effect of this effort is unknown, but not likely to significantly affect the species outside of the limited area where it had been harvested for this trade. Because trade is not a current threat placing the five species of sawfishes at risk of extinction, moving the largemouth sawfish from CITES Appendix II to Appendix I to further restrict trade cannot be considered as an effective measure in reducing the current extinction risk.

### Proposed Determination

Section 4(b)(1) of the ESA requires that we make listing determinations based solely on the best scientific and commercial data available after conducting a review of the status of the species and taking into account those efforts, if any, being made by any state or foreign nation, or political subdivisions thereof, to protect and conserve the species. We have reviewed the best available scientific and commercial information including the petition, and the information in the review of the status of the five species of sawfishes, and we have consulted with species experts. We are responsible for determining whether narrow sawfish (*A. cuspidata*), dwarf sawfish (*P. clavata*), largemouth sawfish (*P. pristis*), green sawfish (*P. zijsron*), and all non-U.S. DPS of smalltooth sawfish (*P. pectinata*) are threatened or endangered under the ESA (16 U.S.C. 1531 *et seq.*). Accordingly, we have followed a stepwise approach as outlined above in making this listing determination for these five species of sawfish. We have determined that narrow sawfish (*A. cuspidata*); dwarf sawfish (*P. clavata*); largemouth sawfish (*P. pristis*); green sawfish (*P. zijsron*); and all non-U.S. DPS of smalltooth sawfish (*P. pectinata*) constitute species as defined by the ESA.

Based on the information presented, we find that all five species of sawfishes are in danger of extinction throughout all of their ranges. We assessed the ESA section 4(a)(1) factors and conclude the narrow, dwarf, largemouth, green, and the non-U.S. DPS of smalltooth sawfish face ongoing threats from habitat

alteration, overutilization for commercial and recreational purposes, and the inadequacy of existing regulatory mechanisms throughout their ranges. All of the threats attributed to the species decline are ongoing except the fishery in Lake Nicaragua that collapsed, presumably with the largemouth sawfish population. After considering efforts being made to protect these sawfishes, we could not conclude the proposed conservation efforts would alter the extinction risk for any of these five sawfishes.

### Effects of Listing

Conservation measures provided for species listed as endangered or threatened under the ESA include recovery actions (16 U.S.C. 1533(f)), concurrent designation of critical habitat if prudent and determinable (16 U.S.C. 1533(a)(3)(A)); Federal agency requirements to consult with NMFS and to ensure its actions do not jeopardize the species or result in adverse modification or destruction of critical habitat should it be designated (16 U.S.C. 1536); and prohibitions on taking (16 U.S.C. 1538). Recognition of the species' plight through listing promotes conservation actions by Federal and state agencies, foreign entities, private groups, and individuals. Should the proposed listing be made final, recovery plans may be developed, unless they would not promote the conservation of the species.

### Identifying Section 7 Consultation Requirements

Section 7(a)(2) (16 U.S.C. 1536(a)(2)) of the ESA and NMFS/USFWS regulations require Federal agencies to consult with us to ensure that activities authorized, funded, or carried out are not likely to jeopardize the continued existence of listed species or destroy or adversely modify critical habitat. Section 7(a)(2) (16 U.S.C. 1536(a)(2)) of the ESA and NMFS/USFWS regulations also require Federal agencies to confer with us on actions likely to jeopardize the continued existence of species proposed for listing, or that result in the destruction or adverse modification of proposed critical habitat. It is possible, but highly unlikely, that the listing of the five species of sawfish under the ESA may create a minor increase in the number of section 7 consultations for high seas activities.

### Critical Habitat

Critical habitat is defined in section 3 of the ESA (16 U.S.C. 1532(5)) as: (1) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the ESA,

on which are found those physical or biological features (a) essential to the conservation of the species and (b) that may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by a species at the time it is listed upon a determination that such areas are essential for the conservation of the species.

“Conservation” means the use of all methods and procedures needed to bring the species to the point at which listing under the ESA is no longer necessary. Section 4(a)(3)(A) of the ESA (16 U.S.C. 1533(a)(3)(A)) requires that, to the extent prudent and determinable, critical habitat be designated concurrently with the listing of a species. Critical habitat shall not be designated in foreign countries or other areas outside U.S. jurisdiction (50 CFR 424.12 (h)).

The best available scientific and commercial data as discussed above identify the geographical areas occupied by the narrow sawfish (*A. cuspidata*), dwarf sawfish (*P. clavata*), green sawfish (*P. zijron*), largemouth sawfish (*P. pristis*), and the non-U.S. DPS of smalltooth sawfish (*P. pectinata*) are found entirely outside U.S. jurisdiction so we cannot designate critical habitat for these species. We can designate critical habitat in unoccupied areas if the area(s) are determined by the Secretary to be essential for the conservation of the species. Regulations at 50 CFR 424.12 (e) specify that we shall designate as critical habitat areas outside the geographical range presently occupied by the species only when the designation limited to its present range would be inadequate to ensure the conservation of the species.

The best available scientific and commercial information on the species does not indicate that U.S. waters provide any specific essential biological function other than general foraging opportunities for the largemouth sawfish (*P. pristis*). All records of *P. pristis* in U.S. waters were larger animals (adults). We are unaware of any record of a juvenile largemouth sawfish in U.S. waters, which suggest the species does not use the area for a nursery. The majority of reports for the largemouth sawfish in U.S. waters are during the summer months when water temperatures are warmer. We have no reports of the species that would suggest U.S. waters are used for breeding. Based on the best available information we have not identified unoccupied area(s) that are currently essential to the conservation of any of the sawfishes proposed for listing. Therefore, based on the available information we do not

intend to designate critical habitat for the narrow, dwarf, largemouth, green, or the non-U.S. DPS of smalltooth sawfish.

#### *Identification of Those Activities That Would Constitute a Violation of Section 9 of the ESA*

On July 1, 1994, NMFS and FWS published a policy (59 FR 34272) that requires us to identify, to the maximum extent practicable at the time a species is listed, those activities that would or would not constitute a violation of section 9 of the ESA. Because we are proposing to list all six sawfishes as endangered, all of the prohibitions of Section 9(a)(10) of the ESA will apply to all six species. These include prohibitions against the import, export, use in foreign commerce, or “take” of the species. Take is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” These prohibitions apply to all persons subject to the jurisdiction of the United States, including in the U.S. or on the high seas. The intent of this policy is to increase public awareness of the effects of this listing on proposed and ongoing activities within the species’ range. Activities that we believe could result in a violation of section 9 prohibitions of these six sawfishes include, but are not limited to, the following:

- (1) Take within the U.S. or its territorial sea, or upon the high seas;
- (2) Possessing, delivering, transporting, or shipping any sawfish part that was illegally taken;
- (3) Delivering, receiving, carrying, transporting, or shipping in interstate or foreign commerce any sawfish or sawfish part, in the course of a commercial activity, even if the original taking of the sawfish was legal;
- (4) Selling or offering for sale in interstate commerce any sawfish part, except antique articles at least 100 years old;
- (5) Importing or exporting sawfish or any sawfish part to or from any country;
- (6) Releasing captive sawfish into the wild. Although sawfish held non-commercially in captivity at the time of listing are exempt from certain prohibitions, the individual animals are considered listed and afforded most of the protections of the ESA, including most importantly, the prohibition against injuring or killing. Release of a captive animal has the potential to injure or kill the animal. Of an even greater conservation concern, the release of a captive animal has the potential to affect wild populations of sawfish through introduction of diseases or inappropriate genetic mixing.

Depending on the circumstances of the case, NMFS may authorize the release of a captive animal through a section 10(a)(1)(a) permit;

(7) Harming captive sawfish by, among other things, injuring or killing a captive sawfish, through experimental or potentially injurious veterinary care of conducting research or breeding activities on captive sawfish, outside the bounds of normal animal husbandry practices. Captive breeding of sawfish is considered experimental and potentially injurious. Furthermore, the production of sawfish progeny has conservation implications (both positive and negative) for wild populations. Experimental or potentially injurious veterinary procedures and research or breeding activities of sawfish may, depending on the circumstances, be authorized under an ESA 10(a)(1)(a) permit for scientific research or the enhancement of the propagation or survival of the species.

We will identify, to the extent known at the time of the final rule, specific activities that will not be considered likely to result in a violation of section 9. Although not binding, we are considering the following actions, depending on the circumstances, as not being prohibited by ESA Section 9:

(1) Take of a sawfish authorized by a 10(a)(1)(a) permit authorized by, and carried out in accordance with the terms and conditions of an ESA section 10(a)(1)(a) permit issued by NMFS for purposes of scientific research or the enhancement of the propagation or survival of the species;

(2) Incidental take of a sawfish resulting from Federally authorized, funded, or conducted projects for which consultation under section 7 of the ESA has been completed, and when the otherwise lawful activity is conducted in accordance with any terms and conditions granted by NMFS in an incidental take statement in a biological opinion pursuant to section 7 of the ESA;

(3) Continued possession of sawfish parts that were in possession at the time of listing. Such parts may be non-commercially exported or imported; however the importer or exporter must be able to provide sufficient evidence to show that the parts meet the criteria of ESA section 9(b)(1) (i.e., held in a controlled environment at the time of listing, non-commercial activity).

(4) Continued possession of live sawfish that were in captivity or in a controlled environment (e.g., in aquaria) at the time of this listing, so long as the prohibitions under ESA section 9(a)(1) are not violated. Again, facilities should be able to provide evidence that the

sawfish were in captivity or in a controlled environment prior to listing. We suggest such facilities submit information to us on the sawfish in their possession (e.g., size, age, description of animals, and the source and date of acquisition) to establish their claim of possession (see For Further Information Contact); and

(5) Provision of care for live sawfish that were in captivity at the time of listing. These individuals are still protected under the ESA and may not be killed or injured, or otherwise harmed, and, therefore, must receive proper care. Normal care of captive animals necessarily entails handling or other manipulation of the animals, and we do not consider such activities to constitute take or harassment of the animals so long as adequate care, including adequate veterinary care is provided. Such veterinary care includes confining, tranquilizing, or anesthetizing sawfish when such practices, procedures, or provisions are not likely to result in injury; and

(6) Any interstate and foreign commerce trade of sawfishes already in captivity that is conducted under a CITES permit.

Section 11(f) of the ESA gives NMFS authority to promulgate regulations that may be appropriate to enforce the ESA. Future regulations may be promulgated to regulate trade or holding of sawfish, if necessary. The public will be given the opportunity to comment on future proposed regulations.

#### *Role of Peer Review*

In December 2004, the Office of Management and Budget (OMB) issued a Final Information Quality Bulletin for Peer Review establishing a minimum peer review standard. Similarly, a joint NMFS/FWS policy (59 FR 34270; July 1, 1994) requires us to solicit independent expert review from qualified specialists, concurrent with the public comment period. The intent of the peer review policy is to ensure that listings are based on the best scientific and commercial data available. We solicited peer review comments on this 12-month finding and proposed rule from three NMFS scientists familiar with elasmobranchs and their comments are incorporated into this document. All three peer reviewers supported our determinations. Prior to a final listing, we will solicit the expert opinions of several qualified specialists selected from the academic and scientific community, Federal and State agencies, and the private sector on listing recommendations to ensure the best biological and commercial information is being used in the decision-making

process, as well as to ensure that reviews by recognized experts are incorporated into the review process of rulemakings developed in accordance with the requirements of the ESA.

We will consider peer review comments in making our determination, and include a summary of the comments and recommendations, if a final rule is published.

#### **References**

A complete list of the references used in this proposed rule is available upon request (see **ADDRESSES**).

#### **Classification**

##### *National Environmental Policy Act*

The 1982 amendments to the ESA, in section 4(b)(1)(A), restrict the information that may be considered when assessing species for listing. Based on this limitation of criteria for a listing decision and the opinion in *Pacific Legal Foundation v. Andrus*, 675 F. 2d 825 (6th Cir. 1981), NMFS has concluded that ESA listing actions are not subject to the environmental assessment requirements of the National Environmental Policy Act (NEPA) (See NOAA Administrative Order 216-6).

##### *Executive Order 12866, Regulatory Flexibility Act, and Paperwork Reduction Act*

As noted in the Conference Report on the 1982 amendments to the ESA, economic impacts cannot be considered when assessing the status of a species. Therefore, the economic analysis requirements of the Regulatory Flexibility Act are not applicable to the listing process. In addition, this proposed rule is exempt from review under Executive Order 12866. This proposed rule does not contain a collection-of-information requirement for the purposes of the Paperwork Reduction Act.

##### *Executive Order 13132, Federalism*

In accordance with E.O. 13132, we determined that this proposed rule does not have significant Federalism effects and that a Federalism assessment is not required. In keeping with the intent of the Administration and Congress to provide continuing and meaningful dialogue on issues of mutual state and Federal interest, this proposed rule will be given to the relevant governmental agencies in the countries in which the species occurs, and they will be invited to comment. NMFS will confer with U.S. Department of State to ensure appropriate notice is given to foreign nations within the range of all five species. As the process continues, NMFS intends to continue engaging in

informal and formal contacts with the U.S. State Department, giving careful consideration to all written and oral comments received.

#### **Public Comments Solicited**

We intend that any final action resulting from this proposal will be as accurate as possible and informed by the best available scientific and commercial information. Therefore, we request comments or information from the public, other concerned governmental agencies, the scientific community, industry, environmental groups or any other interested party concerning this proposed rule. We particularly seek comments containing:

- (1) Information concerning the location(s) of any sightings or captures of the species;
- (2) Information concerning the threats to the species;
- (3) Taxonomic information on the species;
- (4) Information related to the determination of a non-U.S. DPS of smalltooth sawfish;
- (5) Efforts being made to protect the species throughout their current range;
- (6) Information on the aquaria trade of these species; and
- (7) Information on the movement patterns of smalltooth sawfish.

Public hearing requests must be made by July 19, 2013.

#### **List of Subjects in 50 CFR Part 224**

Administrative practice and procedure, Endangered and threatened species, Exports, Imports, Reporting and recordkeeping requirements, Transportation.

Dated: May 29, 2013.

#### **Alan D. Risenhoover,**

*Director, Office of Sustainable Fisheries, performing the functions and duties of the Deputy Assistant Administrator for Regulatory Programs, National Marine Fisheries Service.*

For the reasons set out in the preamble, 50 CFR part 224 is proposed to be amended as follows:

#### **PART 224—ENDANGERED MARINE AND ANADROMOUS SPECIES**

- 1. The authority citation for part 224 continues to read as follows:

**Authority:** 16 U.S.C. 1531–1543 and 16 U.S.C. 1361 *et seq.*

- 2. In § 224.101, paragraph (a), revise the entries in the table for “Smalltooth sawfish” and “Largetooth sawfish”, and add new entries for four new species the “Narrow Sawfish”, “Dwarf Sawfish”, “Smalltooth Sawfish, Non-U.S. DPS”, and “Green Sawfish” at the end of the table to read as follows:



§ 224.101 Enumeration of endangered marine and anadromous species. (a) \* \* \*

\* \* \* \* \*

Species		Where Listed	Citation(s) for listing determination(s)	Citation(s) for critical habitat designation(s)
Common name	Scientific name			
* * * * *				
Smalltooth Sawfish, U.S. DPS	<i>Pristis pectinata</i> .....	Everywhere Found U.S.A. ....	68 FR 15674, Apr. 1, 2003 ...	74 FR 45353, Sept. 2, 2009.
* * * * *				
Largetooth sawfish .....	<i>Pristis pristis</i> ( <i>Pristis microdon</i> ) ( <i>Pristis perotteti</i> ).	Everywhere Found .....	76 FR 40835, July 12, 2011	NA.
* * * * *				
Narrow Sawfish .....	<i>Anoxypristis cuspidata</i> .....	Everywhere Found .....	[Federal Register citation and date when published as a final rule].	NA.
* * * * *				
Dwarf Sawfish .....	<i>Pristis clavata</i> .....	Everywhere Found .....	[Federal Register citation and date when published as a final rule].	NA.
* * * * *				
Smalltooth Sawfish, Non-U.S. DPS.	<i>Pristis pectinata</i> .....	Everywhere Found Outside U.S. Waters.	[Federal Register citation and date when published as a final rule].	NA.
* * * * *				
Green Sawfish .....	<i>Pristis zijsron</i> .....	Everywhere Found .....	[Federal Register citation and date when published as a final rule].	NA.

<sup>1</sup>Species includes taxonomic species, subspecies, distinct population segments (DPSs) (for a policy statement, see 61 FR 4722, February 7, 1996), and evolutionarily significant units (ESUs) (for a policy statement, see 56 FR 58612, November 20, 1991).

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